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A

TREATISE

ON THE

ORIGIN, PROGRESSIVE IMPROVEMENT

AND

PRESENT STATE

OF THE

MANUFACTURE

OF

PORCELAIN AND GLASS.

PHILADELPHIA:
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1846.

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"The arts may be said to imitate nature, or to help, or to overcome and advance nature: nor are they therefore to be esteemed less noble because more practicable, since our best and most divine knowledge is intended for action; and those may justly be counted barren studies which do not conduce to practice as their proper end."

BISHOP WILKINS.

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A

TREATISE

ON THE

PROGRESSIVE IMPROVEMENT AND PRESENT STATE

OF THE

MANUFACTURE

OF

PORCELAIN.

CHAPTER I.

HISTORICAL NOTICES OF THE MANUFACTURE.

Origin of the Art.—Brickmaking.—Potter's Wheel.—Indian Earthenwares.—Roman Water-Pipes.—Remains of Ancient Pottery.—Roman Potteries in Staffordshire.—Antiquity of the Art in the East.—Porcelain first brought to Rome.—Figures found with Egyptian Mummies.—China-Wares brought by Portuguese Traders.—Discovery by De Botticher in Saxony.—Manufacture attempted in France.—Investigations of Reaumur.—Jonas Hanway's Account of Collection at Dresden.—Works at Berlin.—English Potteries.—Plot's Account.—Improvements in Glazing.—White Stone-Ware.—Wedgwood's Improvements.—Exportations by Wedgwood.—His Inventions.—Characteristics of True Porcelain.—Porcelain of Derby.—Of Coalport.—Of Worcester.—Of Rotherham.

THE formation of earthen vessels capable of containing fluid substances is an art of the very highest antiquity. In the rudest stages of society, the want of such vessels would call forth the inventive powers of mankind; and, probably, the hard shells of some vegetable productions, such as gourds and the larger descriptions of nuts, would be first adapted to the purpose. The pliant and infrangible nature of the skins of animals taken in the chase would, at a very early period, point them out as convenient recipients for fluids; but the preparation of these, as well as the fashioning and hollowing of wooden bowls, supposes a previous knowledge of some manual arts, and implies the possession of tools. After even these had been attained, and supposing that the existence of fire, and its use in preparing food, had become known, vessels formed of wood, or of the hides of animals, would be of little use in rendering that knowledge available. Some savage tribes thus circumstanced, have, indeed, made wooden bowls subservient to this purpose, by throwing into the fluids which

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they contain, stones previously heated in the fire. This manner of boiling water, and of cooking provisions, is, however, at best, but an inconvenient process, and would be immediately abandoned upon the discovery that certain earthern substances were endowed sufficiently with the quality of resisting the action of fire.

It must continue matter of doubt, whether the fashioning and hardening of clay was practised first by the brickmaker or by the potter. We know that bricks, thoroughly burned, were used at the building of the tower of Babel, 2200 years before the commencement of the Christian era, and 600 years prior to the carrying away into captivity of the Israelites. That the use of bricks, for the purposes of building, must have become exceedingly common at this last-mentioned period, is evident, from the great numbers of the captive Jews who were compelled by their Egyptian task-masters to prosecute the manufacture. It appears that the bricks then made were not artificially burned; the chopped straw which entered into their composition, and which served to hold the mass together, would, in such case, have been destroyed. Specimens of very ancient Egyptian bricks, which have been brought to this country, confirm the supposition that the heat of the sun was alone employed in baking them.

Many centuries later, the Romans conducted the manufacture of bricks with a great degree of perfection. A comparison of very ancient Roman ruins, with buildings of modern elevation, will show at once how superior are the bricks employed in the former, both as regards solidity and beauty. Specimens of the potter's art, if even any such existed at an equally early period, could not be expected to continue in being for so many ages; if, indeed, they had withstood the destroying hand of time, and descended to the present day, they would not bring with them any direct testimony of their date of production, and could throw little or no light upon the question of priority. It is certain, however, that, in very remote ages, the potter's art had attained to a considerable degree of usefulness, since the earliest authentic records allude to the potter's wheel as to an implement of then high antiquity.

The same wants would arise in different portions of the globe; and in all cases, where similar means for their gratification presented themselves, it is not surprising that these means should be equally embraced by all. Accordingly, it has been found, in newly-discovered countries, and among people comparatively rude and unacquainted with most of the arts which conduce to human convenience, that the use of earthen vessels has been enjoyed for ages before the existence

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of the people was even surmised. Among other proofs of this fact, it may be mentioned, that vases have been found among the aboriginal Indians on the Mosquito shore, which, even by those people, were preserved as memorials of antiquity. There is no reason to doubt that these vessels were the manufacture of the country in which they were found, as the remains of ancient potteries have been discovered at a considerable distance up the Black River on that coast.

There would be little advantage in entering upon an investigation to determine the precise degree of antiquity of the potter's art, if even there existed any sufficient guides to direct us in the inquiry. It will be more profitable at once to forego all fanciful speculations, and to commence the relation of a few facts, and such only as bear the stamp of authenticity. The detail of these need not occupy much time or space, which may be more advantageously devoted to descriptions of the art as it exists in the present day, than to the building up of theories, the truth of which can never be demonstrated.

We learn, on the authority of Vitruvius, who wrote in the Augustan age, that the Romans then made their water-pipes of potter's clay. This people, who introduced a knowledge of the useful arts practised by themselves wherever their conquests were extended, established potteries in England, where, among other articles, similar water-pipes were made. Some of these, about a century ago, were dug up in Hyde Park. They were found to be two inches in thickness, and were firmly jointed together with common mortar mixed with oil.

It has been asserted that the ancient Britons were in the practice of making pottery before the invasion of this country by the Romans; and in support of this belief is brought the fact, that urns of earthenware have been taken from barrows in different parts of the kingdom. On the other hand, the concurring testimony of various writers gives reason for supposing that our ancestors were in those days supplied with such articles by the Venetians. Vestiges of considerable Roman potteries are discernible in many parts of the island, and particularly in Staffordshire, on the site of the great potteries which have so long been carried on in that county. In sinking pits for various purposes, remains of Roman potteries have occasionally been discovered there at a considerable depth below the surface.

Governor Pownall relates, that in his time (1778) the men employed in fishing at the back of the Margate Sands, in the Queen's Channel, frequently drew up in their nets some coarse and rudely-formed earthen vessels, and that it was common to find such pans in the cottages of these fishermen.

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It was for some time believed, that a Roman trading vessel, freighted with pottery, had been wrecked here; but on more particularly examining the spot, called by the fishermen Pudding-pan Sand, some Roman bricks were also discovered, cemented together, so as to prove that they had formed part of some building. Further researches showed that, in Ptolemy's second book of Geography, an island was designated as existing in the immediate vicinity. Such pans as were recovered in a sound state were of coarse materials and rude workmanship—many having very neatly impressed upon them the name of Atilianus; but fragments of a finer and more fragile description of pottery were likewise brought to the surface; and little doubt remains that, during the time of the Roman ascendency in England, a pottery was established here upon an island which has long since disappeared, and that the person whose name has been thus singularly preserved was engaged in its management.

The high antiquity of the art in China, and the proficiency which had been acquired in its pursuit, several centuries before the produce of their manufactories found its way to Europe, will be shown in a future chapter. Porcelain of superior quality was likewise made in Japan at an equally early period; and we learn from Propertius, that at a very remote date, the art was commonly practised in Persia, the vessels manufactured there joining to all the excellencies possessed by the porcelain of China, the quality of resisting the action of fire to a degree which fitted them for being used in the preparation of food.

Most authors who have noticed in any way the state of commerce among the ancients, have referred to the *Vasa Murrhina* particularly described by Pliny,* and mentioned by various Greek and Roman authors. The general opinion was long in favor of these vases having been the true porcelain of China. This opinion has, however, been examined with considerable industry and erudition by M. l'abbé le Bland and M. Larcher, in two dissertations,† whereby it is rendered evident that the Vasa Murrhina were formed out of a transparent stone dug from the earth in some of the eastern provinces of Asia.‡ There is abundant evidence to show that Oriental porcelain was not uncommon in Europe during the first century. The pieces of this manufacture which, according to Pliny, were first seen in Rome, were brought there from Pontus in Asia, by the army of Pompey, 64 years before Christ.

* Nat. Hist. lib. xxvii. † Mém. de Litterat. tome xliii.
‡ Robertson's Disquis. concerning India, second edit. p. 387.

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Little figures covered with a fine deep-blue glaze, which are found deposited with Egyptian mummies, cause it to appear that porcelain was made in Egypt in very ancient times. It is a curious fact, that the coloring matter wherewith these figures are ornamented, and which has been subjected to various chemical tests, affords every indication of its being oxide of cobalt, the identical substance employed for the same purpose by the European porcelain manufacturers of our day, but the use of which was unknown to us until a comparatively recent period. The ore of cobalt was formerly thrown aside by the miners of Saxony as useless, or was employed only in mending roads.*

The Portuguese traders were the means of introducing the fine earthenwares of China into more general use in Europe; and the name assigned to the fabric, as distinguishing it from the coarser descriptions of pottery of domestic manufacture, was most probably given by them—*porcellana* signifying, in the Portuguese language, a cup. It has been attempted to prove a different origin for the name—attributing this to the resemblance which the glazing or varnish, and probably the colors, of porcelain bear to the shells used in some parts of the East instead of money (couries), and which, from the similarity of their shape to that of the back of a little pig, were also called *porcella.*

The possession of porcelain vessels afforded but little insight into the nature of their composition or the mode of their manufacture, as to which many unfounded theories were from time to time proposed. It was long believed, on the authority of Cardan and the elder Scaliger—who, although violently opposed to each other on various and more important subjects, yet agreed in this—that porcelain was made from a mixture of

* "About the end of the fifteenth century, cobalt appears to have been dug up in great quantity, in the mines on the borders of Saxony and Bohemia. As it was not known at first to what purpose it could be applied, it was thrown aside as a useless mineral. The miners had an aversion to it, not only because it gave them much fruitless labor, but because it often proved prejudicial to their health, by the arsenical particles with which it was combined; and it appears even that the mineralogical name *cobalt* then first took its rise. Frisch derives it from the Bohemian word *kow*, which signifies metal; but the conjecture that it was formed from *cobalus*, which was the name of a spirit that, according to the superstitious notions of the times, haunted mines, destroyed the labors of the miners, and often gave them a great deal of unnecessary trouble, is more probable. The miners perhaps gave this name to the mineral out of joke, because it thwarted them as much as the supposed spirit, by exciting false hopes and rendering their labor often fruitless. It was once customary to introduce into the church service a prayer, that God would preserve miners and their works from *Kobolts* and spirits."—*Beckmann, Hist. of Inventions*, vol. ii. pp. 341, 342.

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broken egg and sea shells, which were preparatively buried in the earth for nearly a hundred years.

It was not until the beginning of the 18th century that any light was thrown upon the subject. At that time, the Jesuit, Francis Xavier d'Entrecolles, who was residing as a missionary in China, contrived to elude the jealous vigilance so generally practised towards strangers in that country; and not only obtained specimens of the earths used in the composition of their porcelain, but also acquired some knowledge of the processes employed in the manufacture at King-de-ching. A very circumstantial letter was written by the learned father on the subject, and published by Grosier in his general description of China: but owing to a want of practical knowledge on the part of D'Entrecolles, his descriptions proved so defective in many particulars, as to afford little or no assistance; besides which, it was not until some time after the publication of his letter that any substances similar to the earths transmitted by him could be discovered in France.

About the same time, and while the acquisition of these Chinese specimens was exciting the celebrated Reaumur to their examination, and to the institution of a series of experiments which will be hereafter mentioned, an incidental discovery made by the baron de Botticher, a German alchemist, occasioned the establishment of the porcelain manufacture in Saxony. While prosecuting his vain experiments in search of the philosopher's stone, this man prepared some crucibles, which he observed were caused by the action of heat to assume all the characteristics of Oriental porcelain. Blinded by the avarice which prompted their visionary labors, the adepts of that day seem generally to have turned away from the important discoveries that courted their notice, and which were thus reserved to reward the patient investigations of more philosophic minds in latter times. From this reproach De Botticher is free. The importance of the real discovery thus made was sufficiently apparent, and he had the wisdom to abandon immediately his former pursuit, and to give up the energies of his mind to the establishment of a manufacture, which was, in the end, productive of more beneficial results to himself and to his country, than if he had indeed been successful in his alchemical labors. The world at large did not immediately reap the full benefit of this discovery, as, with a jealousy but too common, the processes used in the Dresden works were veiled in impenetrable secrecy. Up to the period of De Botticher's death, in 1719, only white porcelain was made in Saxony; yet the success with which this manufacture was accompanied, occasioned attempts at imitation in France; and

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porcelain works were established at St. Cloud, and in the Fauxbourg St. Antoine at Paris—the fabrics produced in which, although of beautiful external appearance, were wanting in most of the qualities essential to good porcelain.

The investigations of Reaumur, already alluded to, were undertaken with more rational views, and prosecuted with a more liberal feeling. The result of his researches was communicated by him to the Academy of Sciences, and published by that body in 1727 and 1729. Having procured specimens of Oriental, Saxon, and French porcelains, and broken them, he proceeded to examine their internal structure. The grain in both the Chinese and Saxon pieces appeared compact, smooth, and shining; while that of the French ware was less close and fine, without lustre, and its grain resembled sugar. He next proceeded to ascertain their habitudes on exposure to great heat in a crucible, and reported, that all the European specimens were melted, while that of China remained unaltered. This most essential difference led Reaumur to discover the true nature of porcelain, which is a semi-vitrified compound, in which one portion remains infusible at the greatest heat to which it can be exposed, while the other portion vitrifies at that heat, and enveloping the infusible part, produces that smooth, compact, and shining texture, as well as transparency, which are distinctive of true porcelain. Macquer, in his Chemical Dictionary, asserts, that Reaumur was wrong in classing the Saxon manufacture with the other fusible porcelains of European production; since the materials of which it is composed have always been similar to those of which the China ware is made, one portion being absolutely infusible during the baking.

In his examination of the two porcelain earths received from China, which are called in that country pe-tun-tse and kao-lin, Reaumur made a small cake of each substance, separately, and exposed both to the heat of a porcelain furnace. One, the pe-tun-tse, was fused by this means, without any addition; while the other, kao-lin, gave no sign of fusion. He next intimately compounded the two earths, and found, when the mixture was baked, that it had acquired all the qualities of the finest Chinese ware.

All that was then wanting for the perfect imitation of this admired production was the discovery of materials analogous to the specimen furnished by D'Entrecolles. The search for these was very speedily successful; and the manufacture of porcelain having, from this time, been taken under the royal patronage in France, the works of Sevres produced specimens

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of art which vied successfully with those of Dresden and China.

Mr. Jonas Hanway, in the account of his travels published in 1753, has given a detailed account of the immense collection of porcelain deposited in the Chinese palace at Dresden.

"The vaults of this palace," says Mr. Hanway, "consist of fourteen apartments filled with Chinese and Dresden porcelain. One would imagine there was sufficient to stock a whole country; and yet they say, with an air of importance, that a hundred thousand pieces more are wanted to complete the intention of furnishing this single palace.

"Here are a great number of porcelain figures of wolves, bears, leopards, &c.—some of them as big as the life—a prodigious variety of birds, and a curious collection of different flowers. A clock is preparing for the gallery, whose bells are to be also of porcelain: I heard one of them proved, and think they are sufficient to form any music; but the hammers must be of wood.

"Here are forty-eight large China vases, which appear to be of no use, nor any way extraordinary, except for their great size; and yet his Polish majesty purchased them of the late king of Prussia at the price of a whole regiment of dragoons."

One part of this collection must have been peculiarly interesting, as it exhibited, in an orderly arrangement, specimens of Dresden manufacture laid up by this king of Poland, from the first efforts of De Botticher, through every subsequent gradation; "an idea," says Mr. Parke, "truly philosophical, and which reflects more honor on his memory than the bartering away the liberties of his subjects for pieces of foreign porcelain."

Frederick the Great, when he conquered Saxony, forcibly carried away several of the best workmen from the manufactory at Meissen, near Dresden, and conveyed them to Berlin, where, since that time, a considerable quantity of very good porcelain has been made for the private advantage of the monarch. As many as 500 men are constantly employed in this establishment; but although much of their material is drawn from Saxony, the Prussian porcelain has never equalled in quality that of Dresden.

It is generally believed, that since the time when they were first established by the Romans, potteries have always existed in Staffordshire, but it is certain that until the beginning of the eighteenth century the manufacture was confined to a few objects of the commonest and coarsest description.

The district in this county wherein the great bulk of English manufactured earthenware is produced, is situated about

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a mile from the borders of Cheshire. The potteries commence at a village called Golden Hill, and extend for a distance of more than seven miles, passing through other towns and villages to Lane End. The names of the places comprised in this district, intermediate between the two already mentioned, are Newfield, Smithfield, Tunstall, Longport, Burslem, Cobridge, Etruria, Hanley, Shelton, Stoke, Lower Lane, and Lower Delf. All these have formerly been sufficiently distinct from each other; but the increase of the staple manufacture of the district has called for the erection of so many new potteries and dwelling-houses, that their individuality has been lost, and to a stranger the whole presents very much the appearance of one large town. In every part of the kingdom, except the district itself, the whole are ranked under one general name—that of the Potteries. Etruria is the creation of the celebrated Josiah Wedgwood, by whom the place was thus named after one of the ancient Italian states, celebrated for the tasteful forms it gave to its pottery, specimens of which have materially promoted the improvement of our modern English wares.

In the year 1686, when Dr. Plot published a Natural History of Staffordshire, its traffic in earthenware was very unimportant—being carried on only by the workmen themselves, or by pedlars, who conveyed the pieces in baskets on their backs through the adjoining counties. About the time just mentioned (1690), two brothers, named Elers, came from Nuremberg, in Holland, and settled at Bradwell, where they made an improved kind of red ware, and introduced the art of glazing the vessels by throwing common salt into the oven at a certain period of the baking.* Every precaution was used by the brothers to keep their processes secret; and it is probable that this circumstance, joined to the success of the strangers, excited the enmity and jealousy of their neighbors to the degree which obliged them to leave the country. The pretext assigned for this persecution was the alarm occasioned by the fumes from their kilns during the time of glazing. These fears subsided, however, when the process was continued by their successor. This man, whose name was Astbury, had, it is said, become master of their secrets by a singular stratagem. Feigning to be of weak intellect, and assuming an appropriate vacuity of countenance, he obtained employment in the Bradwell works, and submitted to all the drudgery and contumely which were drawn upon him by his supposed imbecility. By

* The salt is decomposed by this means; and, rising in fumes, the alkali which it contains combines with the silica of the ware, and forms a true glass which covers the entire surface.

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this course of proceeding, he was enabled, unsuspected, to acquire a knowledge of all that was done in the manufactory, and to make models for his own use of all the utensils.

The advantages of this method of glazing with salt were so apparent, that in a short time it was very generally adopted; and on Saturday, the day appropriated to this process, the thick fumes from nearly sixty potteries filled the towns to a degree which darkened the atmosphere, and covered the hills of the surrounding district.*

To Astbury is generally ascribed the introduction of white stone-ware, by the adoption of calcined flints in its composition. The popular version of the origin of this improvement states, that "while travelling to London on horseback, in the year 1720, Astbury had occasion, at Dunstable, to seek a remedy for a disorder in his horse's eyes; when the ostler at the inn, by burning a flint, reduced it to a fine powder, which he blew into them. The potter, observing the beautiful white color of the flint after calcination, instantly conceived the use to which it might be applied in his art."†

The merit of this man has been somewhat overlooked, while contemplating the greater claims to admiration possessed by his more philosophic successor in the course of improvement. That could have been no common mind, however, which led Astbury to the long-continued pursuit of his object, by means so humiliating; and which also enabled him, on the occasion just related, to seize upon a fact thus accidentally presented, and which, although of high importance to his art, might have passed unheeded before the eyes of many a common-place manufacturer.

The step thus made was of consequence in preparing the way for the far greater advances towards perfection, afterwards accomplished by Mr. Josiah Wedgwood. This extraordinary man owed none of his success to fortuitous circumstances. Devoting his mind to patient investigations, and sparing neither pains nor expense in accomplishing his aims, he gathered round him talented artists from different countries, and drew upon the stores of science for aid in pursuing the objects of his praiseworthy ambition. The early and signal prosperity whereby his efforts were attended, served only as a motive urging him forward to new exertions, and as the means for calling forth and encouraging talents in others, in a manner calculated to promote the welfare of his country. Previously to his time, the potteries of Staffordshire produced only inferior fabrics, flimsy as to their materials, and void of taste in their

* Parke, Chem. Cat. p. 125. † Parke, Chem. Cat. p. 126.

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forms and ornaments—the best among them being only wretched imitations of the grotesque and unmeaning scenes and figures portrayed on the porcelain of China. But such have been the effects resulting from the exertions and example of this one manufacturer, that the wares of that district are now not only brought into general use in this country, to the exclusion of all foreign goods, which had before been largely imported, but English pottery has since been sought for and celebrated throughout the civilized world, and adopted even in places where the art was previously prosecuted. An intelligent foreigner, M. Faujas de Saint Fond, writing on this subject, says, "its excellent workmanship, its solidity, the advantage which it possesses of sustaining the action of fire, its fine glaze impenetrable to acids, the beauty and convenience of its form, and the cheapness of its price, have given rise to a commerce so active and so universal, that in travelling from Paris to Petersburgh, from Amsterdam to the further part of Sweden, and from Dunkirk to the extremity of the south of France, one is served at every inn upon English ware. Spain, Portugal, and Italy, are supplied with it; and vessels are loaded with it for the East Indies, the West Indies, and the continent of America."*

It is not among the least of Mr. Wedgwood's merits, that he overcame the disadvantages of a defective education; and, amid the calls of an incessantly active life, found time wherein to school his mind in all the discipline necessary for investigations purely scientific. The ample fortune which he acquired was ever ready for promoting the spread of knowledge, encouraging the efforts of genius, and lessening, as far as possible, the sufferings of his fellow-creatures. His charities, public and private, and especially in his own district, were exemplary and consistent. He gave life to many objects of public utility. The Trent and Mersey canal was undertaken and accomplished through his influence; and by the benefits it has produced to the district, and to its proprietors, has fully approved his wisdom in its promotion.

The principal inventions of Mr. Wedgwood were—1. His *table ware;* the merits of which are, that it has a dense and durable body, and is covered with a brilliant glaze, capable of bearing uninjured sudden and great vicissitudes of heat and cold. This ware, as it was capable of being manufactured with ease and expedition, could be sold at a cheap rate, and would still yield a handsome profit to the inventor. Its various qualities, so superior to any possessed by previous manu-

* Travels in England and Scotland (English translation,) vol. i. p. 97.

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factures of either domestic or foreign production, caused this ware to be taken into immediate and universal favor with the public. Among others, the queen bestowed upon it the tribute of her admiration and patronage; commanded it to be called *queen's ware*—a name which it continues to bear to the present day; and honored Mr. Wedgwood by appointing him her majesty's potter.

2. A *terra cotta*, which could be made to resemble porphyry, granite, Egyptian pebble, and other beautiful stones of the silicious or chrystalline order.

3. *Basaltes*, or black ware. This was a black porcelainous biscuit, having nearly the same properties with the natural stone. It would emit sparks when struck with steel; was capable of taking a high polish; resisted acids; and would bear, without injury, a stronger degree of heat than even the natural basaltes.

4. *White porcelain biscuit.* This ware had a smooth, wax-like appearance, and was possessed of all the properties exhibited by the preceding invention, differing from it only in regard to its color.

5. *Bamboo*, or cane-colored porcelain biscuit, of the same nature as the preceding.

6. *Jasper.* This was also a white porcelainous biscuit, of exquisite delicacy and beauty, having in general all the properties of the basaltes, with this in addition,—that it would receive through its whole substance, from the admixture of metallic oxides, the same colors as those oxides communicate to glass or enamel in fusion. This peculiar property, which it shares with no other porcelain or earthenware body of either ancient or modern composition, renders it applicable in a very pleasing manner to the production of cameos, portraits, and all subjects that require to be shown in bas-relief; since the ground can be made of any color that may be preferred; while the raised figures are of the purest white.

7. A *porcelain biscuit*, possessing several properties that render it invaluable to the chemist, and which have occasioned this invention to be brought into general use in all laboratories. The ware is exceedingly hard, being little inferior in this repect to agate, whence it is peculiarly adapted for forming mortars. It resists the action of the strongest acids and of all corrosive substances, and has the further quality of being perfectly impenetrable by any known liquid.

The investigations of Reaumur, already detailed, make it evident that the characteristics of porcelain, as far as they depend upon semi-vitrification, may be obtained when ingredients wholly fusible are employed, provided the fire be care-

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fully withdrawn from the oven at the precise moment when vitrification has arrived at, and not proceeded beyond, a certain point. Accordingly, this porcelain was, at one time, very commonly produced both in this and other countries. The quality of goods thus composed is always inferior to that of true porcelain; and, if further or again exposed to the heat of the furnace, the substance would entirely change its nature, and run into a vitreous and shapeless mass.

Porcelain of this description, much esteemed for its beauty, was long manufactured at Bow and at Chelsea. It was not until the year 1768, that Mr. Cookworthy discovered certain mineral substances in Cornwall similar in their properties to the porcelain earths of China; and having secured to himself, by patent, the exclusive right of using those materials, was the first person who made true porcelain in England.

In practising this art, Mr. Cookworthy, and those to whom he afterwards assigned his patent right, attained to considerable success as regarded the quality of their manufactures, although the demand for their goods did not prove proportionate to the money expended in bringing the processes to perfection. One probable cause for the inadequacy of their remuneration, existed in the successful efforts of Mr. Wedgwood, which have been already detailed, for improving the quality of common earthenwares made in Staffordshire, whereby foreign porcelain was rendered less an object of desire, and consequently its successful imitation was no longer considered as being of any great importance.

The extent to which, in the year 1785, this manufacture had arrived, and its importance to the three great interests of the country—landed, maritime, and commercial—may be collected from the evidence then given by Mr. Wedgwood before a committee of the privy-council, and at the bars of the two houses of parliament. The question at that time under the consideration of the legislature, and upon which these examinations were taken, arose out of the proposal of government to abolish the system of commercial restrictions and disabilities then existing between Great Britain and Ireland, and to render the intercourse between the two divisions of the empire nearly as free and unrestricted as that between the counties of Durham and Northumberland; a proposition so perfectly natural and reasonable in itself, that, but for the possession of records wherein they have been preserved, we might really be at a loss to conjecture the nature of the arguments whereby it was opposed and defeated.

In the course of the discussions to which this subject gave rise in the house of lords, the marquess of Lansdowne, remark-

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ing upon the evidence given by the respectable merchants and manufacturers at the bar of the house, declared that the result to which he in his own mind had arrived was the very opposite to the conviction which they had adopted. "Though much valuable information may," said his lordship, "doubtless, be derived from their evidence, it must not be forgotten that they are men peculiarly subject to prejudice and error, in all cases where their personal interests are concerned. Were any one, for instance, to ask a manufacturer of Halifax, what is the greatest crime upon earth? Is it felony, is it murder, is it parricide? No! he would answer; it is none of these—it is the exporting of WOOL."

In later times, we have seen this measure of justice and sound policy more successfully brought forward; and it is acknowledged that each country has since been reaping benefits in consequence, upon the inevitable arrival of which nothing but the strongest commercial prejudices and national jealousy could have thrown even a momentary doubt.

Mr. Wedgwood, in the course of the evidence already alluded to, thus remarks:—"Though the manufacturing part alone in the Potteries, and their immediate vicinity, gives bread to 15 or 20,000 people, yet this is but a small object when compared with the many others which depend on it; namely, 1st, The immense quantity of inland carriage it creates throughout the kingdom, both for its raw materials and finished goods. 2d, The great number of people employed in the extensive collieries for its use. 3d, The still greater number employed in raising and preparing its raw materials in several distant parts of England, from near the Land's End, in Cornwall—one way along different parts of the coast, to Falmouth, Teignmouth, Exeter, Pool, Gravesend, and the Norfolk coast; the other way to Biddeford, Wales, and the Irish coast. 4th, The coasting vessels, which, after having been employed at the proper season in the Newfoundland fishery, carry these materials coastwise to Liverpool and Hull, to the amount of more than 20,000 tons yearly; and at times when, without this employment, they would be laid up idle in harbor. 5th, The further conveyance of these materials from those ports, by river and canal navigation, to the Potteries, situated in one of the most inland parts of this kingdom; and, 6th, The reconveyance of the finished goods to the different parts of this island, where they are shipped for every foreign market that is open to the earthenwares of England."

Mr. Wedgwood very justly observed further, that this manufacture is attended with some circumstances of advantage which are almost peculiar to itself; viz. that the value of the

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finished goods consists almost wholly in the labor bestowed upon them; that every ton of raw materials produces several tons of merchandise for shipping, the freight being paid, not upon the weight, but according to the bulk; that scarcely a vessel leaves any of our ports whose lading is not in part made up of these cheap, bulky, and, for these reasons, valuable articles, to this maritime country; and that fully five parts in six of the aggregate manufactures of the Potteries are exported to foreign markets.

Important as were the advances which at that time had been made in the art, Mr. Wedgwood was still of opinion that they could be considered but as the beginning of improvements,—that these were still but in their infancy, and but of little moment when compared with those to which the art was capable of attaining, through the continued industry and growing intelligence of the manufacturers, in combination with and fostered by the natural facilities and political advantages enjoyed by the country; an opinion fully borne out by the event, and which our progressive experience shows to have been founded on clear and accurate perceptions.

The manufacture of earthenwares in England is far from being restricted to the district in Staffordshire which has been described already as having acquired the name of "the Potteries." Establishments for making the commoner kinds of wares are to be found in many and various parts of the kingdom; at Lambeth, especially, several manufactories of stone pottery have been carried on for considerably more than a century, producing articles which have never been surpassed in any country, either for the excellence of their materials and workmanship, or for the magnitude of the vessels and the variety of uses to which they are adapted. The Lambeth ware may, in fact, be pronounced perfect of its kind.

Porcelain has long been made at Derby, and at Coalport, near Colebrook Dale, in Shropshire. Establishments have subsequently risen in the city of Worcester, wherein very beautiful specimens are produced; and yet more recently, the manufacture of excellent porcelain has been engrafted upon a long-established pottery for commoner wares, situated at Swinton, near Rotherham, in Yorkshire. At the Rockingham works, which have been so named in compliment to their early patron, the celebrated marquess of Rockingham, porcelain is now produced which vies successfully in every kind of excellence with that of older English establishments. Among many other specimens which attest the proficiency of the Yorkshire manufacturers, two may be more particularly mentioned, which are deserving of more than common attention as denoting the

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degree of advancement to which the art has reached in England.

One of these pieces is a copy in enamel colors, made on a porcelain tablet, from an original painting by Vandyke, and now in the possession of the noble inhabitant of Wentworth Castle. The subject of the picture is, "The earl of Strafford occupied in dictating his defence to his secretary." The execution of this copy does justice to the masterly original; and, in regard to expression and coloring, has been pronounced equal to the most admired productions of the Sevres works. The other specimen is remarkable not only for elegance of design, and the goodness of the workmanship, but also because it is believed to be the largest piece of porcelain that has hitherto been made in this country. It is a scent-jar, forty-four inches high, made and fired in one entire piece. The base, or plinth, is triangular, having a circular projection at each angle; from these rise lions' paws, upon which the globular body of the jar is supported. The scent is allowed to escape through hexagonal openings in the neck. The jar is divided into three compartments, by as many rustic handles of knotted oak; while branches of the same tree, with their rich foliage rising from the plinth, are spread tastefully over the lions' paws, and thence entwining with the handles, rise and encircle the base of the neck. The ornaments of the cover are in keeping with those of the jar, it being covered with branches and foliage of the oak: the whole is surmounted by the figure of a rhinoceros. The three compartments into which the jar is divided are enriched with highly finished paintings in enamel colors, executed by one of the proprietors of the works, from designs by Stothard, the subjects of which are drawn from the admirable romance of Cervantes. The circular projections at the base, and the cover, are adorned with paintings from nature, of six subjects of rare botanical plants, the originals of which are in the conservatories of Wentworth Castle. The whole is relieved and enlivened by ornamental work, in burnished and chased gold; and the work, both in its design and execution, is highly honorable to the artists.

Up to a comparatively recent period, the manufacture of earthenwares formed one of the very few branches of domestic industry which were left free from the evil effects of direct taxation, and, except in one branch, of very minor importance, the art is still in the enjoyment of this immunity; to which favorable circumstance may be imputed much of the signal and uniform success whereby it has been attended. In the year 1812, when the duty upon glass bottles was doubled, the manufacturers of these represented to the chancellor of the ex-

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chequer. [illegible] bottles, the latter, being wholly unprotected, would have an unfair advantage, and might be sold at prices that would drive glass bottles out of use. This was a line of argument not unwise unpalatable to the minister, who readily caught at the suggestion of a new object for taxation: and a duty of five shillings on each hundredweight was immediately imposed upon all stone bottles the content of which should be two quarts and under.

The levying of this duty calls for the attendance of revenue officers at all hours on the premises of every stoneware manufacturer throughout the kingdom: and it is very much to be doubted whether, in any one year since its first imposition, the expenses of collection have not more than absorbed the whole amount paid by the potters. The total quantity of stoneware made which is chargeable with the duty does not exceed 800 tons annually, and a large proportion of this is used for purposes to which glass has never been applied. It is not very likely that stoneware, the utility of which for many purposes is exceedingly great, would ever have been brought into competition with a material so much lighter, and in many respects so much more convenient, even had the pottery continued free from the domiciliary visits of the exciseman; and now that the experiment has been fairly tried during nearly twenty years, and has been found unproductive of any real revenue, there can be no sufficient reason for continuing the impost.

CHAP. II.

GENERAL DESCRIPTION OF INGREDIENTS USED IN THE MANUFACTURE.

Different branches of the art.—Ingredients used.—Properties of Alumina.—Its infusibility.—Contraction when exposed to heat.—Wedgwood's Pryometer.—Composition of Gems.—Great abundance of Clay.—Properties of Silica.—Its great abundance.—Sea sand.—Incapable of artificial solution in water.—Dissolved naturally.—Springs at Carlsbad.—Boiling fountain in Iceland.—Fusion of Silex.—Kinds of Clay used in Potteries.—Their various merits.—China clay of Cornwall.—Mode of its preparation.—Its analysis.—Cornish Felspar.—Its fusibility.—Steatile.—Earth of Baudissero.—Its analysis.—Cornish sopestone.—Spuma maris.—Its employment in porcelain works in Spain.

THE art of manufacturing pottery and porcelain naturally divides itself into four different and distinct branches: the first of these comprehends a knowledge of the nature and peculiar properties of the various materials, whereof the vessels are composed; the second comprises the methods used in combining these materials, and in fashioning the vessels; the third branch

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includes the choice and management of the colors and enamels employed in painting and ornamenting the wares, together with the operations necessary for their conversion; and the last division embraces the means required for completing the manufacture by the aid of fire. In describing, however, the different stages of the manufacture as they occur, the painting and baking processes must unavoidably be intermingled.

The chief ingredients employed in the composition of all kinds of pottery are clay and flint: these are both classed by chemists among the primitive earths. The first of them, in its state of purity, is denominated *alumina*, or oxide of aluminum; and the latter is called *silica*, or oxide of silicium. It is only since the year 1754 that alumina has been acknowledged as a peculiar substance; and the period is much more recent when the researches of Davy proved it to belong to the class of metallic oxides.

It is of great importance to make choice of a suitable kind of clay for the manufacture; but, according to the remark of the celebrated Vauquelin, it is much more important to combine this with a due proportion of flint, as good pottery differs from that which is inferior less in the original quality of its elements than in their proportions.

Clay is an opaque and non-crystallized body, of dull fracture, soft enough in all states to take a mark from iron; when breathed on it exhales an odor which, from its peculiarity, takes its name from the material, and is termed argillaceous. This is owing to the oxide of iron which is mixed with it, as clay, when absolutely pure, does not emit any odor. Clay forms with water a plastic paste, having considerable tenacity, and which, by the action of heat, is brought to a very great degree of hardness: it is compact, smooth, and almost unctuous to the touch, and when dry, may be easily polished by the finger. It is not soluble in water, but mixes readily with it in all proportions, parting with difficulty from the last portion of that which it has absorbed: it will adhere to the tongue. The description of clay employed by potters is infusible in the heat of a porcelain furnace, where some kinds, owing to their being combined with oxide of iron, assume a red color, while others become of a pure white. The highest temperature to which clay can be exposed tends only to increase its density, hardening its substance and diminishing its volume. This diminution of volume produced by increased temperature is an apparent deviation from the general law of expansion by heat; but the deviation is only apparent, and is probably produced by the vaporization of liquid, combined with the clay. Mr. Wedgwood found that the diminution of volume produced by exposing the clay to these ex-

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treme temperatures, continued the same after the clay was suffered to cool, and therefore that its amount admitted of deliberate and accurate measurement. He also supposed (though erroneously) that the shrinkage of the clay was always proportional to the temperature to which it had been exposed. This led to his well-known invention of the pyrometer, an instrument for measuring degrees of temperature beyond the range of the common thermometer. The instrument consisted of small cylinders, composed of two parts of the porcelain clay of Cornwall, and one part of pure alumina. These, when baked in a low red heat and then cooled, were constructed of such a size as just to enter between the wider extremities of two brass rods, fixed on a plate twenty-four inches long, half an inch asunder at one end, and three-tenths of an inch at the other. These rods were divided to tenths of an inch, and consequently each division formed the 240th part of the whole length. The clay cylinders, being exposed to the heat which was required to be determined, were subsequently inserted between these bars, and by reason of their contraction they advanced between them to a point depending on the amount of their shrinkage.

This pyrometer, however, has been found to be subject to a fatal defect. The shrinkage of the clay does not depend on the temperature alone of the fire to which it is exposed, but also on the length of time which the fire has acted upon it. Thus a lesser degree of heat will produce the same shrinkage as a greater degree, provided the clay is exposed to the former for a longer portion of time. The instrument has been, consequently, long since totally laid aside.

Some of the most valued among the precious stones, such as rubies, sapphires, emeralds, jaspers, and others, are composed of either alumina or silica, or of the two earths in combination, together with different small portions of lime, or oxide of iron, or magnesia, &c. The different kinds of clay are most abundantly spread over the globe, forming in many situations entire mountains, in other places existing in vast beds, and elsewhere lying among other mineral substances disposed in strata. It has been generally held that clay results from the slow decomposition of silicious and aluminous rocks, which being acted on by water filtrating through them, their constituent parts have, in the course of ages, been separated; the lighter and finer portions remaining united at the top, while the grosser but less tenacious parts have been resolved into sandy deposits.

Silica, or pure flint, which forms the second material in the composition of pottery, has been considered as a primitive earth. It is of very common occurrence in most parts of the world, in

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primitive mountains. It is frequently found in great abundance embedded in chalk. In Scotland and Ireland it occurs in secondary limestone. Flint abounds in alluvial districts in the form of gravel: an inexhaustible supply of excellent quality might be collected on some parts of the sea-coast of England, and particularly at and near Brighton, where there is enough of this material, known under the name of shingle, to serve the whole manufacturing wants of England for ages to come, while its removal would be attended with advantage to the place whence it should be taken. Flint is silica in a state nearly approaching to purity, its constituents being

Silica	98.
Lime	0.50
Alumina	0.25
Oxide of iron .	0.25
Loss	1.
	100.

It is usually gray, with occasional striped delineations occurring in its substance. It it obtained generally in rolled pieces, but often occurs in irregular shapes. It has internally a glimmering lustre; its fracture is conchoidal, and its fragments are sharp-edged. It is translucent. When two pieces are rubbed together in the dark, they emit a phosphorescent light, and give off a peculiar smell. We are unable to dissolve silex in water. This process is, however, constantly performed by nature. The investigations of Klaproth enabled him to detect 25 grains of silex in 1000 ounces of the principal mineral spring at Carlsbad, in Bohemia; and the celebrated boiling fountain at Rykum, in Iceland, deposits so considerable a quantity of silicious earth, that a solid cup has been formed around it, rising to a considerable height. This solution of silica is probably owing, in both these cases, to the solvent power of soda; which is also present in the water. The water from the spring at Rykum used formerly to be projected into the air to the perpendicular height of 60 or 70 feet; but the overthrow of a mass of rock having since partially covered its orifice, the stream spouts out laterally to a distance of 50 or 60 feet. The heat of the liquid, after it has reached the surface, is sufficient to raise the thermometer to the boiling point of water; and there is little doubt that the fluid must have parted with some portion of its heat on emerging into the atmosphere. The capability of water, in its dense or liquid state, to assume, under these circumstances, a higher degree of heat than that at which it boils under ordinary atmospheric pressure, may be partly at-

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tributable to the depth from which it is brought, influenced by the same law that occasions fluids to boil at lower temperatures on the tops of high mountains. Silica is also found existing in solution in the Bath waters.

The best flints are of a dark gray color, approaching to black, and having a considerable degree of transparency. Those which exhibit brown or yellow spots on their interior surfaces should be rejected, on account of the ferruginous particles which they contain, and which would occasion blemishes in the ware. Those larger masses of flint are always most preferred by the potter, which, being dark and clear within, are covered with a white crust externally. The rolled pieces which are taken from chalk pits are mostly of this description.

De Saussure asserts that pure silex may be fused at a heat equal to 4043 degrees of Wedgwood's pyrometer; a degree so far beyond any that has yet been observed, that one is at a loss to know upon what data the assertion is founded.

The clay principally used in the potteries of Staffordshire is brought to them from Dorsetshire and Devonshire. These earths are both of excellent working quality, and, being free from any impregnation of iron, are valuable for the great whiteness which they exhibit when burnt. The Dorsetshire clay is brought from the Isle of Purbeck. It is of two kinds, distinguished as brown clay and blue clay: that from Devonshire comes from the southern part of the county, and is also of two distinct qualities, which are known as black clay and cracking clay. The clay from Dorsetshire is considered preferable to that from Devonshire for the potter's use; so that it commands a price in the potteries equal to one eighth more than the latter.

The good qualities of brown clay are, that it burns of an excellent white, and is not liable to crack during the process of burning. On the other hand, it is subject to the considerable imperfection of *crazing*,—an evil which induces some manufacturers to discard it altogether from their works. Crazing is a technical phrase, used to denote the cracking of the glaze, which is believed to arise from the imperfect manner in which this is capable of uniting itself with the clay composing the body of the vessel. This defect of crazing is not, however, always referable to the cause here assigned, but may be owing equally to the faulty nature of the glaze, which may not be capable of perfect fusion in the heat of the kiln; or it may result from the error of the workmen in withdrawing the wares from the kiln at too early a period, and before they are properly cooled; the glaze, which is in fact glass, requiring great carefulness in this respect for its proper annealing, and being, with-

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out it, very liable to crack with every material variation of temperature to which it may be suddenly exposed.

Blue clay combines the greatest number of good qualities, and is the most generally esteemed, of all the four descriptions here mentioned. It burns exceedingly white, forms a very solid quality of ware, and is capable of being advantageously combined with a greater quantity of silicious earth, or flint, than any of the other kinds; a quality which is desirable, because the greater the proportion of silica that is used, the whiter will prove the ware: the limit to the use of flint being the inability of the clay to bear it in combination beyond a certain proportion without cracking. Both these descriptions of clay are much used as ingredients in the manufacture of porcelain.

Black clay owes its distinctive color to the quantity of coaly or bituminous matter which it holds in combination, but which is entirely consumed and dissipated when the clay is submitted to the heat of the oven, leaving the articles of which it is composed of a very good white; and which is, indeed, found to be the more perfect in proportion as the clay has originally been blacker. Cracking clay has acquired its name from an evil property of occasioning the ware to crack while undergoing the first application of fire. To compensate in some degree for this evil, the goods in which it is employed prove of an extreme whiteness. Much judgment and experience must be brought to the employment of this clay, that its tendency to cracking may be as much as possible corrected by a proportionate admixture. If clay of any description were dried without the addition of any other body, after being made sufficiently plastic to be modelled on the potter's wheel, it must inevitably crack, as the evaporation of its water will occasion it to shrink in the proportion of one part in twelve during the drying.

Another description of clay, much prized for the manufacture of finer kinds of earthenware and porcelain, was found in Cornwall by Mr. Cookworthy, as already mentioned, and is commonly denominated China clay. This is very white and unctuous to the touch, and is obviously formed by the gradual disintegration of the felspar of granite. There are found in Cornwall large mountains of this mineral, some of which are thus partially decomposed; this China clay proves, on examination, to be identical with the kao-lin of the Chinese. It was found by Mr. Gerhard in the course of some experiments upon granite (which is a compound of quartz, felspar, and mica,) that the felspar was melted into a transparent glass, that the mica was found lying under it in the form of a black slag, while the quartz remained unaltered.

The China clay of Cornwall is prepared by the clay mer-

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chants on the spot where it is found. The stone is broken up into pieces of a small size, and then cast into a running stream: there the light argillaceous parts are washed off and held suspended in the water, while the more ponderous mica and quartz remain at the bottom of the stream. At the end of the rivulet the water is stopped by a dam, and the pure clay gradually subsides. When this deposit is completed, the clear water is drawn off, and the solid matter dug out in square blocks, which are placed on shelves, and exposed to a continued current of air until sufficiently dry to be packed in casks for shipment. This clay, which is then in the state of a fine powder, is very smooth, and of an extreme whiteness. Mr. Wedgwood found by analysis that it contains sixty parts of alumina and twenty parts of silica. The manufacturers are required to pay a much higher price for this than for any other of our native earths, but for some finer purposes it is altogether indispensable.

A portion of undecomposed Cornish felspar is often added to the clay, on account of its fusibility and tenaciousness, by which it binds, as it were, the whole ingredients more closely together. The fusible quality of felspar is owing to the presence of about an eighth part of potass. If this alkaline substance be separated by decomposition, as is the case with the China clay above described, the fusibility no longer exists, and the body remains unaltered in the greatest heat of a porcelain furnace. The use of this material has of late been very much increased in our porcelain works. It is a curious and very useful fact, that although neither clay, flint, nor lime can be separately melted, yet when mixed together in due proportions, the mass is fused without difficulty, the one mineral acting as a flux to the other.

Steatite, or soapstone, has of late years been very much employed in the composition of porcelain. When present, in even a small proportion, it limits the contraction of the ware in the furnace. Steatite is a sub-species of mica, which is found abundantly in Cornwall, and is met with also in the island of Anglesea. The mineral which forms the porcelain earth of Baudissero, was long considered to be a superior kind of clay, until it was discovered by M. Geobert that it contains not a particle of alumina in its composition. This chemist, on endeavoring to convert the substance into alum, found, to his great surprise, that he obtained only crystals of sulphate of magnesia (Epsom salts). Proceeding thence to analyze it carefully, he ascertained its composition to be, magnesia 68, carbonic acid 12, silica 15·6, sulphate of lime 1·6, water 2·8. The soapstone of Cornwall differs from this substance, yielding on analysis, magnesia 44, silica 44, alumina 2, iron 7·3, magnesia 1·5, chrome 1·2. It also contains traces of lime and muriatic acid.

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In a published letter addressed by M. Proust to M. Vauquelin from Madrid, mention is made of a beautiful kind of porcelain produced in that city, and which is described to be of a texture even harder than the porcelain of France. Instead of employing the kao-lin, the body of the ware is made with spuma maris, a species of pot-stone found in the neighborhood of Madrid, and the glaze is composed of felspar brought from Gallicia. The pot-stone when taken from the quarry is sufficiently soft to admit of its being cut with a knife like soap. Besides magnesia, silex, and some particles of argil and lime, it contains a portion of potass, the presence of which, in the competent opinion of M. Proust, contributes not a little to the superior quality of the manufacture.

CHAP. III.

ON THE PREPARATION OF MATERIALS.

Dilution of Clay.—Chemical Examination of Water necessary.—Rain Water.—Carefulness of German Manufacturers.—Blunging.—Machinery.—Preparing Flints.—Burning.—Breaking.—Grinding.—Dry Grinding.—Brindley's Improved Mill.—Chert.—Care required in selecting Grinding Stones.—Dilution of Flint-Powder.—Proper Consistence of Dilution.—Admixture in due Proportions.—Affinity of Alumina for Silica.—Slip.—Slip-Kiln.—Method of evaporating superfluous Moisture.—Working the Paste.—Time necessary for tempering it.—Proportions wherein Clay and Flint are united.—Difficulty of ascertaining this.—Slapping.—French Manufacturers.—Proportions of Ingredients used by them.—Kao-Lin.—Flint.—Gypsum.—Broken Porcelain.—Calcined Bones.—Tender Porcelain.—Its Composition.—Porcelain Earth used in Berlin.—French Potters buy their Materials ready mixed.—Advances on this Plan.—Ineligible in England.

In preparing the clay, the first operation of the pottery is that of mixing it with water to the consistence of cream. It is well known, that water collected from springs, and from many streams, contains various foreign matters, some of which would be injurious to the composition of porcelain. It is therefore necessary to examine chemically the properties of water before it is employed for this purpose, in order to make choice of that which is purest; and to correct, by some of the well-known means, any bad qualities that may be present. The French manufacturers are accustomed to employ only rain water, whose near approach to purity fits it for the object. In Germany, still more precise in his operations, the manufacturer prepares his materials only twice in the year, at the vernal and autumnal equinoxes; persuading himself that at these seasons there is some peculiarity in the rain which better qualifies it for

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the purpose of his manufacture. Although the grounds for this nicety are not apparent, it would savor of presumption to attribute the practice entirely to prejudice. The observations of men practically engaged in manual or chemical operations have frequently led to improvements in processes long before the reasons whereon these should have been founded have been revealed by scientific researches.

The mixing of the clay, which is called *blunging*, is effected in a trough five feet long, three feet wide, and two and a half feet deep. In order fully to break down the clay, and incorporate it with the water, a long wooden instrument, terminated with a blade at one end and a cross handle at the other, is moved violently about in the trough in all directions; and this becomes an operation of great labor. In large establishments, where machinery is employed for the management of labor, the blunging is thus effected.—The clay is thrown into a cast iron cylinder, four feet deep, and twenty inches in diameter. Through the centre of this cylinder runs an upright shaft, furnished with knives placed as radii at right angles to the shaft, but so arranged upon it that their flat sides are in the plane of a spiral thread, so that in the revolutions of the shaft, the knives perform the double office of cutting whatever stands in their way, and of forcing downwards the contents of the cylinder in the manner of a screw. Another set of knives is inserted in the interior surface of the cylinder, and these extend to the shaft in the centre, parallel to, and corresponding with, the revolving knives: thus the two sets, the one active and the other passive, have the effect of shears in cutting the clay into small pieces; while this, in its reduced state, is at the same time forced through an aperture at the bottom of the cylinder, and transferred to a vat for the purpose of being mixed with water; a process which this previous dividing of the clay is found materially to facilitate.

The vat where this mixture is performed is likewise of a cylindric form, its diameter being equal to four times its depth. In the centre of this vat, also, a perpendicular shaft is inserted, furnished with cross arms or radii, one below the other. These cross arms are connected by upright staves, giving the appearance of two opposite gates hung upon the central shaft. These revolve within the cylinder; and as they are partially immersed in the pulp, the constant agitation mixes all the finer particles of clay with the water, while stony particles of greater magnitude fall to and remain at the bottom. The pulp, now mixed to the consistence of cream, is passed off from the vat through a series of sieves of increasing degrees of fineness, which are worked to and fro by machinery; thus a separation is effected

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between the grosser parts and that portion which is fitted to enter into the composition of the ware.

The next process is that of preparing the flints. These are first burnt in a kiln constructed for the purpose, and which very much resembles an ordinary lime-kiln, being of a conical shape, and about nine feet deep. While the flints are yet red-hot, they are removed from the kiln, and in that state are thrown into cold water; by means of which their attraction of aggregation is lessened, so as to facilitate greatly the subsequent operation of grinding: they are next broken, either by manual labor, or by machinery. In the latter case they are placed upon a strong iron grating, and there struck by hammers, until sufficiently reduced in size to fall through the grating to a receiver, whence they are conveyed to the flint mill.

In order to expedite the process, and at the same time to grind the flints finer, a quantity of water is thrown with them into the mill. Another good attending the presence of water in this grinding operation, is the preservation of the health of the workmen. Before the adoption of this method, the atmosphere of the room became charged with the finer particles of flint, which, adhering to the lungs, frequently occasioned distressing and sometimes fatal diseases to the workmen. This great improvement was effected by the illustrious Brindley, who likewise invented the mill now used in the process. This is a large circular vat, about thirty inches deep, having a central step fixed in the bottom to carry the axis of a vertical shaft. The moving power is applied to this shaft by a crown cog wheel placed on the top. At the lower part of the shaft, and at right angles to it, are fixed four arms, upon which the grinding stones are fixed; large blocks of stone of the same kind being likewise placed in the vat. These stones are a very hard silicious mineral, called chert, which is found in abundance in the neighborhood of Bakewell, in Derbyshire. The broken flints being then introduced and completely covered with water, the axis is made to revolve with great velocity, when the calcined flints are speedily reduced to an impalpable powder.

The nature of the grinding stones used in these flint mills is of considerable importance; for should they contain any calcareous carbonate, they will be abraded; some part of their substance will mix with the flint, and consequently with the body of the wares, and thus occasion very serious injury to the manufacturer. Some years ago, a very heavy loss was sustained by some potters, who had purchased flints ground in a mill the stones of which contained carbonate of lime.

When the flints are thus sufficiently ground, the semi-fluid

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is transferred to another vat, also [illegible] with an upright shaft furnished with arms or vanes for the purpose of agitation; and a considerable quantity of water being added, the machinery power is applied, and the whole violently agitated. The process occasions the grosser and heavier particles to take their place at the bottom, while the finer portions remain in suspension above; and in this state is passed into a reservoir, whence in due time the supernatant water is drawn off through apertures provided for the purpose.

The dilution of clay is held to be of the proper consistence for mixing, when a quantity that will fill a pint measure weighs twenty-four ounces; and that of the flint is considered suitable for use, when the same bulk weighs thirty-two ounces. It is by these specific gravities, that is, by the comparative densities of these substances as indicated by weighing an equal bulk of each, that the manufacturer is enabled to ascertain the real proportions of the materials and to combine them in the degrees which the experience leads him to employ for the composition of various kinds of ware. Too much nicety can hardly be given to this important part of his labors.

The dilutions of clay and flint being brought together in suitable proportions, and intimately mixed by agitation, the mixture is passed, while in a state of semi-fluidity, through different sieves, in order to separate any remaining impurities together with such portions as have not been sufficiently ground. By these means the mass presents the utmost uniformity and smoothness throughout. The affinity which subsists between silica, under all circumstances, is so great, that they will unite even in the humid way, forming a kind of mortar; and when this becomes hardened by time, it is thereafter incapable of decomposition by the action of the atmosphere.

This fluid mixture of clay and flint is called *slip*, and, after passing through the sieves, is pumped to the *slip kiln*. This is a kind of trough formed of fire-bricks; its size varies according to the extent of the manufactory, being of the length of forty to sixty feet, from four to six feet wide, and about twelve to eighteen inches deep. Flues from fire-places pass under the whole extent of the troughs, in which the fluid is made to boil, and the process of evaporation is slowly conducted, so as to produce an uniform consistency throughout the mass. This evaporation must be very carefully attended, and the mass frequently stirred and turned over, otherwise, from the imperfect manner in which it conducts heat, the portion in contact with the bricks would become improperly hardened, while the remainder would continue fluid; in addition to which, flint being

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specifically heavier than clay, the former would in the first part of the process, and while the slip is yet fluid, have a natural tendency to subside to the bottom, and thus render the composition of the mass unequal.

The evaporation is never carried beyond a certain point in the kiln; for should the mass become too dry, it would be impossible to knead it properly, or to mould it on the wheel into any of the forms which it is desired to create. The place where this evaporation is performed is called the *slip-house.*

When the clay or paste is removed from the slip-kiln it contains a great number of air-bubbles, and must be well incorporated together or tempered by working or beating it with wooden mallets. It is next cut with a kind of spade into small pieces, which are thrown upon the mass with all the strength of the workmen, and these operations are persisted in until it is supposed that their further continuance would not bring the whole to a more complete state of consistence.

The mixture, when brought to this state, should be suffered to remain in a mass for a considerable time before it is used; the material by this course becomes much more intimately united than can ever be effected by mechanical means. It is to be feared that, although the English potters are fully aware of this fact, they yet fail to adopt so eligible a practice, which, as it calls for the employment of greater space, time, and capital, is neglected for other advantages, which, if not so great in an extended point of view, are certainly more immediate.

It is not possible to state the precise proportions wherein the clay and flint are brought together in our English potteries. Each manufacturer has in this respect his own practice, which, esteeming it as the best, he endeavors to keep profoundly secret; and, besides, the proportions necessarily vary with the quality and properties which it is desired to give to the manufacture. Vauquelin informs us that silex forms at least two thirds of all kinds of pottery; alumine from one fifth to one third; lime from 1-500th to 1-2000th part; and iron from the smallest conceivable quantity up to twelve and sometimes even fifteen per cent. The presence of the two latter bodies is accidental, arising from the natural composition of the materials, and in particular the oxide of iron, when present in any sensible degree, renders the clay unfit for all purposes, except that of forming the common red ware.

Parkes, whose practical essay on the making of earthenware and porcelain is founded on his own personal observations, made during a residence of some years' continuance at the seat of manufacture, is yet so little able to be precise upon the sub-

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ject of proportions, that is, tells us first whether a fourth, a fifth, or a sixth part by weight of the prepared paste.

Some portion of the china-clay of Cornwall enters into the composition of every better kind of earthenware, except only the cream-colored sort. This ingredient is sometimes called the mass, and mingled with it, and at other times is mingled separately and mixed in the required proportion with the rest.

The clay or paste when taken up has undergone the process of *slapping*. This alone is sufficient to give a considerable strength, and increases in value as it is more slapped, from fifty to sixty pounds being a convenient size to work. The mass is then cut through with a thin wire, one end of which is held in either hand, while the part between is forced through the clay, which separates as easily as if it were cut with a knife; then laying in with both hands the piece thus separated, and exerting its utmost strength, it hurls it on the rest of the mass; and this operation is repeated until the whole lump exhibits a perfectly smooth and close appearance wherever it is cut. So complete is the incorporation of the whole mass by this means, that if at the commencement of the process, two pieces of clay of different colors are taken, the lump at its completion will be of one uniform tint, intermediate to the two original colors. This laborious operation is one of the very first necessity, in order completely to expel every air-bubble, however minute, remaining in the clay, and which could not be so thoroughly driven out by its previous beating in the larger mass when taken from the slip-kiln. If the air were not thus thoroughly expelled, it would become so much rarified and expanded in the oven, that it would force out a passage for itself, and by blistering, spoil or much injure the goods.

Some of the more considerable among the potters, who employ steam power for blunging the clay and grinding the flints, perform this operation of slapping by the same agency, saving thereby both time and labor. In this case the expulsion of the air is effected by mechanical pressure, and the office is performed with perhaps as much efficiency as by hand.

Having undergone all these preparations, the clay is now fit for being shaped upon the wheel or fashioned by the aid of moulds into all the diversified forms which fancy may desire. This branch of the art is divided into three different departments—throwing, pressing, and casting—either of which is used according to the form of the article manufactured.

The manufacturers of porcelain in France do not use so much secrecy as is preserved in our own potteries, with respect either to the materials whereof their ware is compound-

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ed, or to the proportions wherein these are employed. The clay which forms five parts in six of the whole mass, is the porcelain earth already mentioned as being identical with the kao-lin of China; to this are added in certain proportions flint and gypsum (plaster of Paris), both calcined and ground; and fragments of broken porcelain, which must be white, also ground to a fine powder. One rule for forming this composition assigns nine parts each of flint and broken porcelain, and four parts of calcined gypsum, to each one hundred parts of porcelain clay. Another authority recommends five parts of gypsum and only eight parts of ground porcelain; while the flint and clay are used in the same proportions as in the first rule. If at any time the manufactory should not afford broken porcelain for the purpose, it is recommended that pieces be compounded, about a quarter of an inch thick, of the other three ingredients, wherein the proportions of gypsum and flint are augmented; and these pieces, having been previously converted into porcelain by baking, are to be ground and mixed in the above-mentioned proportions with the other ingredients.

It has of late years been the practice of some English manufacturers to use a considerable proportion of calcined bones, together with a small quantity of gypsum, in combination with china-clay, flint, Cornish stone and enamel. By this means porcelain of a brilliant and very transparent white is produced, which, however, is deficient in density, and very liable to crack on the application of hot liquids.

Several among the chemists and scientific manufacturers of porcelain in France have given recipes for the composition of tender porcelain, although this description of ware is no longer made in that country.

This kind of porcelain will support, without softening, a greater degree of heat than suffices to melt glass. It is semi-transparent, has a vitreous fracture, and returns a clear sound when struck by a hard body. It is harder but not so brittle as glass, and bears, without injury, sudden and very considerable alterations of temperature.

M. Brongniart recommends a mixture of one part of pure white clay, with three parts of a frit compounded of nitre soda, alum and selenite (sparry gypsum), together with a large proportion of ferruginous sand and a little common salt. The ingredients of this frit are to be calcined together, and the whole intimately kneaded; when cold, the compound is to be reduced to powder, and in that state mixed with the clay.

This paste is not so cohesive or viscous as that which forms hard porcelain, and greater carefulness is, therefore, called for in fashioning vessels with it. Lime and selenite, or any similar

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earths which, if fused by themselves, produce a transparent and colorless glass, may answer the same purpose as the frit just mentioned. In making choice, however, of the compound to be thus used, it must be borne in mind, that the paste must not be more stubborn in resisting fire than the *seggars*, or vessels wherein it is inclosed during the baking, and no greater proportion of any substance that promotes fusion must be used than can be supported by the clay without having its cohesiveness greatly diminished.

The porcelain earth used in Berlin is compounded with silicious sand and sulphate of lime in crystals. The constituents of their flux are varied in the proportions according to the quality of the ware it is intended to produce. In the greater part of the German manufactories felspar is used, and some employ a calcareous sand.

When tender porcelain was made in the works at Sevres, a small portion of arsenic entered into its composition. This was found very hurtful to the workmen. Few of the turners or moulders, after following their employment for some years, escaped severe pulmonary complaints; and to this disadvantage is ascribed the order of the French government under which this branch of the manufacture has been discontinued in that establishment.

Individual manufacturers of porcelain in France avoid all the labor of preparing their materials, and purchase these in a state of readiness from establishments at Limoges where the best porcelain earth is found. The price of the compound, when delivered in Paris, or at an equal distance from the place of preparation, does not exceed three sous—about one penny halfpenny of our money—per pound.

This arrangement must considerably simplify the operations of the manufacturers, and lessens the amount of capital which they must employ in the establishment of their works; but it is doubtful whether the accompanying disadvantages are not fully equivalent to these benefits. There are many reasons to render such a plan ineligible in this country.

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The extension of the art, and the consequent competition among the manufacturers in France since the return of peace, have compelled them to use the utmost economy in their various processes; so that, while the quality of their goods has been fully sustained, the prices have been importantly lowered. These savings have been partly realized through the increased skill of the workmen, but are more referrible to the smaller proportionate quantity of fuel consumed, which has arisen, not from any further improvement in the form of their kilns, but through a better arrangement in filling them, whereby they are now made to contain, at each baking, nearly one third more of pieces than was formerly customary.

The potter's oven is now always made of a cylindrical form, and very similar to the common kilns used for burning tiles, with the external appearance of which every one is familiarly acquainted. The furnace mouths of the oven are placed at certain intervals around it; from these the fire and heated air pass into horizontal flues in the floor, and thence ascend through all the interstitial spaces between the bungs, until the surplus heat escapes through an aperture in the centre of the roof.

The Chinese subject the greatest part of their porcelain to only one firing, drying the pieces sufficiently in the air to prepare them for glazing. This plan they are able to pursue, because the nature of their materials is such as to resist the entrance of water. Their glaze, the composition of which will be hereinafter described, is much superior to any used in European potteries, but requires the most intense degree of heat for its fusion, and considerable art is consequently required for the management of the fire, as well as in the construction of their ovens. These are built in a most substantial manner, so that when the fire is at its greatest height, the hand may be applied to the outside without any fear of burning. The draft is promoted by placing the oven at the extreme end of a long narrow passage, which acts as a funnel in supplying air for supporting combustion, the intensity of which is regulated by four or more side apertures, or registers, which are opened or shut according as the heat is required to be augmented or moderated. The hearth is placed in front, and occupies the whole breadth of the oven. The pieces which are placed in seggars, are artfully disposed in the oven, in the manner already described as followed in England. When the fire is lighted, the furnace door is walled up, leaving only an aperture large enough for the introduction of fuel. The heat is raised gradually during about thirty hours, after which time fuel is incessantly supplied by two men, who relieve each other at intervals. The wood used for this purpose is very carefully dried and cut into slender bil-

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rated, and proceeds to give the first form to the vessel. This is done either by his fingers alone, or with the aid of an instrument shaped according to the desired form. The instruments employed for this purpose are called profiles or ribs. By the assistance of one of these, the inside is smoothed and made to assume the requisite shape, and any inequalities, technically called *slurry*, are removed. When it is wished to make any number of vessels exactly similar to each other in shape and dimensions, certain pegs are fixed as a gauge without the circumference of the revolving board, but placed in such a manner, that whenever the plastic clay is brought to coincide at the requisite points with the gauge, the thrower knows that the article has attained the proper dimensions.

In this manner most circular-shaped vessels are formed. When finished to the artist's satisfaction, he proceeds to remove his work, cutting it from the lathe by passing a thin brass wire through the lowest part of the clay. The vessel is then lifted off and placed on a board or shelf, where it is left to dry partially before it is farther smoothed and shaped in the *turning-lathe*.

When the vessel is so far dried as to be in that particular state of hardness well known to the workmen, and which is called the *green state*, it is in the most favorable circumstances for the performance of the remaining operations of turning and smoothing, for being furnished with handles, spouts, and such appendages as cannot be affixed in its first formation.

For making circular dishes, plates, saucers, or shallow bowls, and other vessels of that class, a plaster mould is used. This is slightly sprinkled with powdered porcelain, sifted through a fine cloth, and placed on the block which surmounts the upright spindle of the lathe. The block being then set in motion, the clay is fashioned in the first place by the hand of the workman, which presses it against the mould, and afterwards with a profile to give the requisite internal form. If any ledge or foot is required, it is affixed afterwards with slip, in the manner hereafter described as employed for joining handles and spouts. All superfluous parts are cut away, and the whole is finished by means of a horn tool and a damp sponge. When sufficiently dry to be taken from the moulds, the edges are pared with a sharp knife, and the pieces are slightly polished by the hand. After this, they are placed in piles of four, six, ten, or more, according to their weight and solidity, and are left to harden, preparatory to their being put in the oven.

The *turning-lathe* of the potter is similar to that used by the turner in wood. The end of the spindle has a screw thread, upon which are screwed *chucks* of wood, tapered in their form,

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heat from the surrounding atmosphere, which is again supplied by neighboring objects, until an equilibrium of temperature is restored.

The proprietors of potteries are accustomed to furnish vases, urns, and other pieces of ornamental shapes, in the state of biscuit, to ladies who exercise their taste and ingenuity in embellishing them by painting and gilding. Being then returned to the manufacturer, the glaze is applied, the baking is finished in the gloss oven, and the gilding is burnished by means that will be described hereafter.

If it were attempted to apply the glaze to articles of porcelain and earthenware, without their previous conversion into biscuit, their texture and shape would be injured by the absorption of water from the glaze. Neither would it, for the same reason, be possible to ornament the ware by painting, or to transfer patterns to their surface by printing. There is another reason given for the necessity of this previous baking, in the greater contractibility of the clay than of the glaze, which would crack or peel off if the limit of contraction had not been previously attained. It will be remembered that the shrinking of clay upon the application of heat is permanent, and that no alteration of its bulk will occur, unless it be subjected to a still higher degree of temperature. By limiting, therefore, the heat of the gloss oven in which the baking is finished, below that applied to the biscuit, the evil of cracking the glaze, through the contraction of the ware, is avoided.

The glaze usually employed for common kinds of earthenware is compounded of litharge of lead and ground flints, in the proportion of ten parts by weight of the former to four parts of the latter. Cornish granite is sometimes substituted for flint, and used in the proportion of eight parts to ten of litharge. This method of glazing is objectionable, on account of the injury which, notwithstanding every precaution that can be taken, it occasions, in its application, to the health of the workmen employed, who frequently are seized with paralysis; and because the lead, which is soluble by means of acids, and highly poisonous, renders vessels thus glazed improper for preparing or containing many articles of human food.

The bad effect of raw glazes upon their health, is greatly lessened to the workmen when they can be brought to the frequent use of ablutions. In every pottery the men employed in glazing should be, and in most establishments they are, plentifully supplied with soap, which they are enjoined to use on every occasion of quitting their work. Unfortunately, however, the workmen themselves have become erroneously impressed with a belief in the superior efficacy of ardent spirits in ward-

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ing off or counteracting the poisonous effects of lead, and fly to the use of this as a specific, to a degree which too often proves, both physically and morally, worse than the evil which it is intended to prevent.

The mixtures just mentioned are called raw glazes; their employment is convenient to the potter because of their cheapness and extreme fusibility. Flint, which remains unaffected in the focus of the most powerful lens, is, when combined with lead, melted and vitrified at a comparatively low heat. The method of using this glaze is to reduce the ingredients to the state of a fine powder, and throw them into as much water as will make them of the consistence of thin cream. The mixture must be well stirred, that the powders may be always kept uniformly blended throughout the fluid. The pieces are first brushed to free them from dust, and then merely dipped into the liquid and withdrawn, when they must be turned rapidly about in all directions, that the glaze may flow equally over the whole surface. The superfluous liquid having been allowed to drain off for a few seconds, and the pieces having been set on a board during a few minutes, they are ready for insertion in the seggars.

Chaptal, in his "Chemistry applied to the Arts," has given a process for forming white enamel, which answers well for glazing the superior kinds of earthenware and tender porcelain. Equal parts of lead and tin are kept in fusion until completely oxidated. The powder thus formed is ground with water, all impurities are removed by repeated washings, and being dried it is kept for use. The whitest flints are then chosen, and fused with carbonate of potash, the latter being in such proportion to the flint, that the mixture will be soluble in water. To the solution of flint thus made, muriatic acid must, from time to time, be added, until no further precipitation occurs. The precipitate thus obtained is pure silex, which, being washed and dried, is also fit for use. If then one part of this silex, and one part of the metallic oxide, be added to two parts of carbonate of potash, and the whole be fused in a crucible, the mass need only be reduced to a fine powder to prepare it for use in glazing.

Mr. John Rose, of the porcelain works at Coalport in Shropshire, speaks in commendation of a glaze for hard porcelain which he has used for some time, and which having been examined by competent artists, at the request of the Society of Arts, has been reported on very favorably. Mr. Rose's glaze is composed of 27 parts of felspar, 18 of borax, 4 of Lynn sand, 3 of nitre, 3 of soda, and 3 of the China clay of Cornwall. This mixture is melted together and ground to a fine powder; 3 parts of calcined borax being added previously to the grinding.

Glazes for porcelain and the finer kinds of earthenware are

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generally made with white lead, ground flints, ground flint-glass, and common salt; Lynn sand combined with soda, as a flux, being frequently added to the ingredients just mentioned. Almost every manufacturer uses a peculiar glaze, the recipe for which is kept secret by him as much as possible, under the idea of its superiority compared with that employed by his competitors, so that it is not possible to state proportions with accuracy. The French porcelain makers have given the composition of hard glazes made by them, which are all said to be formed of flint, ground porcelain, and crystals of calcined gypsum, in the following different proportions:—

	No. 1.	No. 2.	No. 3.
Calcined flint	8 parts	17 parts	11 parts.
Ground porcelain	15	16	18
Crystals of calcined gypsum	9	7	12

It is necessary to vary the composition of the glaze, in order to suit the different materials that form the body of the ware, since that would be a very fine glaze for one mixture of earths, which would be wholly inappropriate to another, proving deficient in lustre and being liable to crack. Before adopting any glaze in conjunction with a particular kind of ware, it is most prudent to make trial of it upon a small scale, in order to prove the suitableness of the bodies to each other.

This branch of the potter's art is greatly indebted to the extraordinary perseverance of a single man, Bernard de Palissy, a native of France, who was born in Agen at the close of the fifteenth century. His parents occupying an humble station in life, he was entirely indebted to his own unquenchable energy and perseverance for the success which crowned his industry.

The original occupation of Palissy was that of a draughtsman, to which pursuit he added land surveying. Accident having thrown into his hands an enamelled cup, he was immediately seized with the desire of improving the art, and thenceforward relinquishing all other occupations, gave up his whole time, mind, and substance, during several years, to the prosecution of experiments on the composition of enamel. He has himself given a narrative of his labors, sacrifices, and sufferings, during the progress of his pursuit, which is intensely interesting.

In this account, Palissy represents himself as alternately planning and building, demolishing and rebuilding his furnace, at every step buoyed up by hope, and as often met, but not subdued, by disappointment; the object of remonstrance and derision to his associates, subject to the expostulations of his wife, and witness to the silent but more eloquent reproaches of his children. In other respects Palissy proved himself an amiable

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as well as a highly-gifted man; for, notwithstanding that his efforts were ultimately crowned by success,—that standard whereby the judgment of mankind is most easily and therefore most usually formed,—one might hesitate to applaud a degree of perseverance which, for so long a time, materially interfered with the welfare of his family. Amidst all this scene of deprivation and disappointment, Palissy bore outwardly a cheerful countenance, and, throughout the lengthened trial, confined within the dungeon of his own breast those feelings of bitterness which he has so forcibly described as being his portion.

The extremities to which he was at one time reduced were such, that to provide fuel for feeding the furnace, his furniture and afterwards even some of the woodwork of his dwelling was destroyed; and in order to silence the clamor of his assistant workman for the payment of wages, he stripped himself of a portion of his apparel. At length, however, these efforts were rewarded by complete success; and fame, honors, and independence were thenceforward his attendants through a long career of useful occupation.

Palissy's after pursuits were of a more general character, embracing the sciences of agriculture, chemistry, and natural history, upon which subjects he both wrote and lectured with ability and success.

Nor did the firmness of his character forsake him for a moment to the end of his life. Being a Protestant, and having ventured, in some of his lectures, to promulgate facts which made against the dogmas of the priests, he was, when in his ninetieth year, dragged by the infuriate zeal of these fanatics to the Bastile, and died, with consistent firmness, within its walls. His heroic reply, while thus imprisoned, to Henry III. is above all praise. "My good man," said the king, "if you cannot conform yourself on the matter of religion, I shall be compelled to leave you in the hands of my enemies."—"Sire," replied the intrepid old man, "I was already willing to surrender my life, and could any regret have accompanied the action, it must assuredly have vanished upon hearing the great king of France say 'I am compelled.' This, sire, is a condition to which those who force you to act contrary to your own good disposition can never reduce me; because I am prepared for death, and because your whole people have not the power to compel a simple potter to bend his knee before images which he has made."

So great is the competition among potters in the present day, that means which are injurious to their real quality are frequently adopted for rendering their wares less costly. Some makers are hence tempted to the employment of materials that

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will enable them, at a moderate price, to furnish articles apparently good, but which will speedily prove defective when brought into use. The saving which the manufacturer is able to effect, through the adoption of an inferior glaze, consists not so much in the actual cost of its component parts, as in the smaller quantity of fuel required for its vitrification, and in the shorter period of time demanded for its conversion.

The earthenwares offered, at low prices, by hawkers and pedlars, and at inferior shops, are mostly composed of clay that will not bear a proper degree of heat in the oven, and are covered by a glaze so tender as to craze after a few cleansings with hot water. If exposed to a high temperature, or if acids be applied, the glaze will be dissolved, and the vessels consequently rendered useless. The quantity of lead which enters into the composition of the better kinds of glazes is so small, that the deteriorating and pernicious effects which attend upon the use of raw glaze need not be apprehended from their employment.

The seggars used to inclose the wares when baked in the gloss oven, are similar to those employed in the first firing. Previous to their insertion, the pieces must have the glaze wiped from the parts which immediately rest upon the bottoms of the seggars, otherwise they would adhere and might be broken in their removal. The cases are piled up in the manner already described, and just that degree of heat must be employed which will give perfect fusion to the glaze and cause it to spread regularly over the surface. The temperature, of course, varies according to the quality of the articles and the composition of the glaze; but, for the reason already stated, it must never be carried beyond the degree to which the biscuit has been previously exposed. In practice, the temperature of the gloss oven is generally less by about ten degrees of Wedgwood, or 1300 degrees of Fahrenheit's scale, than the heat of the biscuit oven.

As alkaline substances are so powerfully instrumental in promoting the fusion of intractable bodies, it may be thought, that by increasing their proportion when combined with felspar, glazes might be formed that would fuse at a heat sufficiently moderate for any description of earthenware, and that, consequently, the use of oxide of lead, which is so pernicious, might be altogether abandoned: but another serious evil which would then be experienced prevents this substitution. The glaze, if it contained beyond a certain portion of alkali, would not undergo the same degree of expansion by heat as the body whereon it is laid, and would, as a consequence, crack to such a degree as, when brought into use, would allow any greasy

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matter to penetrate through to the body of the ware; and this would speedily destroy its coherency.

The qualities which it is the object of the manufacturer to give to porcelain of the finest description, are density, whiteness, transparency, and fine texture of the glaze. These properties are estimated in the order wherein they are here enumerated, compactness of body being the point which it is considered most desirable to attain. The glaze, as seen in the finished porcelain, should not put on a lustrous appearance; but while beautifully smooth to the touch, should present to the eye rather the softness of velvet than the gloss of satin. This peculiar semblance will only be produced with glaze that melts with difficulty, and when the heat has been raised precisely to, and not beyond, the point that is necessary for its fusion.

Stoneware is a very perfect kind of pottery, and approaches nearer than any other description to the character of porcelain. Its body is exceedingly dense and compact, so much so, indeed, that although vessels formed of it are usually glazed, this covering is given to them more with the view of imparting an attractive appearance than of preserving them from the action of liquids. When properly made and baked, stoneware is sufficiently hard to strike fire from flint, and is as durable as porcelain.

This kind of earthenware is composed of clay and flint. The proportion in which these ingredients are used is said to vary in different manufactories, and it is difficult to ascertain the precise quantities employed in any. The grinding and dilution of the materials is effected in the manner already described, and when these have separately been thus treated, their union is commonly effected in the proportion of about eighteen measures of argillaceous to fourteen measures of siliceous fluid. Any larger proportion of flint would render the compound more difficult to be worked; and if much less were used, the baked ware would not present a sufficiently smooth and shining appearance.

The best descriptions of this ware have very long been made in the potteries at Lambeth, the proprietors of which procure their supply of clay from Devonshire and Dorsetshire, and purchase flint already ground from Staffordshire, where this material can be afforded at a cheaper rate than would attend its preparation so near the metropolis.

The plan introduced by the two brothers Elers is still pursued, of glazing these goods by the decomposition of common salt thrown into the kiln, at or near the conclusion of the baking process. Other glazes are likewise employed for many articles, and, according to the usual system, the particular components of

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these are also veiled in mystery; ground glass is, however, understood to be the basis of all.

One of the most considerable of the Lambeth potters has recently announced the discovery of a glazing compound, which is sufficiently fusible without containing a particle of lead, and which has been proved capable of altogether resisting the action of acids; it is used by him for coating the insides of jars and bottles of all descriptions.

The different colors observable on the outer surface of drinking jugs and other articles, are owing to the partial use of a glaze, the part to which this is applied becoming dark in the heat of the kiln, while the glazing of the light colored portion is caused, as before mentioned, by the introduction of salt.

The fashioning of stoneware pottery is in all respects conducted similarly to the processes already fully described. Seggars are mostly employed for inclosing the pieces during the baking, which usually occupies about forty-eight hours.

Vessels of considerable size, some being capable of containing sixty imperial gallons, are made in this manner, and are found highly useful in performing many chemical operations connected with the arts.

CHAP. VI.

ON THE ART OF APPLYING COLORS AND ENGRAVINGS TO EARTHENWARE.

Antiquity of Enamel Coloring.—Specimens from Ancient Egypt.—From the Royal Works at Sèvres.–Painted Ware of Worcester—Of Staffordshire—Of Derby—Of Yorkshire.—Great Services of Mr. Wedgwood in this Branch of the Manufacture.—Mystery in the Preparation of Colors.—Publication of Processes by M. Brongniart.—Metallic Oxides—Addition of Fluxing Bodies necessary—And why.—Colors Employed for tender and for hard Porcelain.—Vehicle used with the Colors.—Mode of their Combination.—Description of Colors —Purple and Violet.—Red.—Yellow.—Blue.—Green.—Brown.—Black.—White.—Compound Colors.—Precautions necessary in Forming those Compounds.—Gilding.—Lustreware.—Preparation of Colors.—Enamelling Kilns.—Trial Pieces.—Method of Gilding and Burnishing.—Copperplate Engravings.—Mode of Transferring Impressions to Earthenwares.—How Performed in France.

THE art of painting on earthenware, although of comparatively recent introduction into England, is by no means a modern invention. It is well known that the ancients manufactured colored enamels; and some specimens of the art, performed by the Egyptians more than three thousand years ago, have been preserved to the present day, which is an evidence of this fact; showing us, at the same time, that, in so remote an

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age, the artists of Egypt were possessed of sufficient practical knowledge of chemistry, to avail themselves of processes which have been brought to light anew by scientific investigators of more modern times.

Recently, the art has been carried to an admirable degree of perfection in Europe. Some specimens are preserved in the porcelain works at Sèvres, of which the French artists are justly proud; while the performances in our own potteries at Worcester, in Staffordshire, at Derby, and yet more recently in Yorkshire, are such as entitle them to be placed in an equal rank with those of our continental neighbors.

When, about seventy years ago, Mr. Wedgwood commenced the series of improvements, by which his name has been rendered so deservedly celebrated throughout Europe, no attempts at embellishment had been made in the English potteries; and if ornamented services of porcelain were seen on the tables of the wealthy, they were always of foreign, and generally of oriental production. So soon, however, as, by the intrinsic merit of his wares, this enterprising manufacturer had secured not only the patronage of royalty, but the more solid support of his countrymen in general, he called into action the crucible of the chemist, and the pencil of the artist, and led the way in bestowing that degree of outward embellishment on his productions, which converted them into objects of elegance, and at once encouraged and gratified the growing taste for luxury among the higher classes in this country.

The system of mystery still preserved in the English potteries, in all that respects the composition and glazing of wares, was likewise long practised with regard to the preparation of colors. If, at any time, a manufacturer had found out a preparation more advantageous than that in use before, he always endeavored to limit the benefit of the discovery to his own works; a desire more easy of accomplishment formerly than it has become since the more general diffusion of the light of science. M. Brongniart, at one time director of the national manufactory of porcelain at Sèvres in France, has the merit of being the first who published a correct statement of the most approved plans for preparing and combining the metallic oxides used in coloring porcelain and glass. The employment of these substances for such purposes had been long before and commonly practised, and the art was even carried by some of its professors to a high degree of perfection; but, as M. Brongniart observes, no attempt had been made at the time his essay was written (1801), to apply to it the principles of chemical science; and such pretended descriptions as had then been published contained no theory, and consequently no general principles.

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Where even the authors did offer explanations, these were founded upon the most ridiculous hypotheses; so that all improvements were rather the offspring of chance than the result of systematic inquiry.

It would afford but little satisfaction, or information, to relate by what steps the art now under consideration was reduced into a system, and thus became, in some measure, deserving of the name of a science. It will be sufficient to state the means by which that art is now rendered available in the best conducted porcelain works. In a great part of the following description, the lucid statements given by M. Brongniart in his essay will be closely followed; since, with scarcely any variation, the same processes have been used in both the French and English establishments to the present day.

In this branch of the art there are various objects to be considered, a proper acquaintance with which is necessary to success. Such are, the composition of colors; the fluxes which are necessary to render these fusible, which unite them to the wares, and in many cases impart brilliancy to their tints; the vehicle employed in laying on the colors, and the course to be pursued in fixing them on the porcelain by means of heat.

Metallic oxides form the bases of all vitrifiable colors, but every metallic oxide is not proper for being employed in decorating porcelain. Some are highly volatile, as the oxides of mercury and of arsenic. Others part so freely with the oxygen they hold in combination, that their color proves uncertain, and varies with every application of heat; such are the puce-colored and red oxides of lead, and the yellow oxide of gold. Oxides which are susceptible of great variations are very seldom employed. Black oxide of iron is not used alone for producing that color on porcelain; and the green oxide of copper, as formerly prepared, was so uncertain that it was very rarely employed; but this evil has, since the time of M. Brongniart, been greatly remedied.

Oxides uncombined with other substances are not susceptible of fusion; and although they may be attached in thin strata to vitrifiable bodies by a very violent heat, yet their colors, with the exception of lead and bismuth, would, in such case, become dull, and possibly be even destroyed. In order to promote their fusion, a flux is therefore added, the composition of which varies according to the means employed for diluting the colors at the time they are used. Where a volatile oil is chosen for this dilution, a flux composed of glass, nitre, and borax is most proper; but when, as in the Sèvres manufactory, gum-water is substituted for this volatile oil, the flux must be varied, because borax cannot be properly diluted in gum-water. A compound of glass,

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lead, and silex is therefore preferred by M. Brongniart, who, however, has given no directions regarding the proportions wherein these bodies must be brought together. The other menstruum, which is recommended by M. de Montamy, in his treatise on painting in enamel, is composed of

Powdered glass 40 parts.
Calcined borax * 22
Refined nitre - 44

It is indispensable, not only that the borax and nitre be as pure as they can be rendered, but also that the glass shall not contain the smallest particle of lead in its composition. These ingredients must first be well triturated together in a glass mortar, with a pestle of the same material, during an hour, and then exposed in a crucible to the heat of a charcoal fire, until the swelling, which for a time accompanies the fusion of the mass, has ceased.

By means of this flux the colors are fixed upon the porcelain, and made to assume a resplendent appearance: the metallic oxides, being enveloped by the flux, are preserved from all contact with the air, and their color is rendered permanent; the fusion having been promoted at a temperature too low for their destruction.

Trial should be made of the habitudes of different colors in combination with their flux, in order to determine the exact quantity to be employed with each. Various substances vitrify with greater or less facility when thus combined, and the greatest carefulness and skill are consequently required, so to proportion the relative quantities of each, that not more of the flux shall be added than is necessary to cause a perfect vitrification. If too little were used, the colors, although they might attach themselves to the porcelain, would nevertheless be dull; and if too much, the colors would run, their outlines would not be sufficiently decided, and all the finer touches of the artist would disappear. It has been remarked, that colors which require for their fusion more than six times their weight of flux, do not flow with sufficient facility; and, as they cannot be applied with a pencil, so as to produce a satisfactory result, should be rejected.

Such metallic oxides as would have their colors altered by a strong or often repeated heat, are employed after being mixed with their flux, but without having been previously fused with it. In many cases metallic oxides are first fused with the requisite proportion of their flux, and are then ground for use.

* Mr. Tilloch remarks (Philos. Mag. vol. li.) that borax should be used sparingly, as it causes efflorescence, and promotes the decay of the ename colors.

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Enamel is glass made opaque by the oxide of tin, and rendered fusible by the oxide of lead. All glazes that contain lead participate in the properties of enamel. Raw glazes used for covering tender porcelain are of this nature. The colors employed in painting this porcelain are those which serve for painting in enamel; they require less flux than others, because the surface to which they are applied becomes soft enough to be penetrated by them. Hard porcelain, whose nature is identical with those of China and Saxony, has two kinds of colors applied to it. Those of the first kind, which are used in the representation of different objects, are baked in a heat much below that necessary for baking porcelain; while the other colors, which are few in number, must be exposed to the highest degree required by the porcelain itself. The glaze used for hard porcelain has little or no lead in its composition. The Sèvres manufacturers, and some few in England, employ felspar without any mixture of lead. This glaze, when exposed to the heat of the gloss oven, dilates, and its pores are opened without becoming soft, so that the colors are not absorbed by it, and do not undergo those changes which occur when they are applied to tender porcelain, where, by mixing with the body of the enamel, they become faint and indistinct. This effect is much increased likewise where some particular colors are employed, and especially the reds produced from iron, which are exposed to the destructive action of the oxide of lead that is contained in the glaze. Painting on tender porcelain must, for these reasons, be several times retouched with the pencil, in order to give to it the distinctness and brilliancy which follow the use of the same colors on hard porcelain, so that a high degree of ornament is seldom or never given to any but the latter description. In the embellishment of hard porcelain, these retouchings are not required, except for the most elaborate specimens of the art, which can by such means, however, be produced with the most admirable degree of perfection, so as to render paintings on porcelain not distinguishable from the finest productions of the pictorial art, without reference to the body upon which it is performed, or to the means used for bringing out the colors; natural objects, landscapes, portraits, and even historical pieces being represented with all the truth, as well as with all the brilliancy of coloring, which distinguish the works of the first masters.

One great inconvenience attends the repeated exposure to the heat of the oven of pieces thus retouched; the colors being liable to peel off, unless the greatest care has been used in their application. This defect has been remedied in the Sèvres works, by introducing a calcareous flux into the felspar glaze,

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which softens it, without at all affecting the body of the ware. Soda and potash are never used as fluxes, as their introduction causes the colors to scale; the reason for which is, that, becoming volatile in a great heat, they abandon the color, which then will not adhere to the glaze.

The liquid matter which serves as a vehicle in laying on the colors, is rubbed with them upon a glass palette until the whole is intimately united. The mixture must be brought to that state of dilution which is most proper and convenient for its application with a hair pencil on the surface of the porcelain. Great care is used in the choice and management of these diluent liquids, which must always be sufficiently volatile to be entirely dissipated in the heat to which the wares are afterwards exposed. In France, the preference is given to oil of lavender as a vehicle; and in order to insure the proper degree of fluidity, this oil is divided by distillation into two parts: that which first comes over, being the most volatile, and having the least density, is used for diluting the colors when they become too thick; and, on the other hand, the portion that remains in the retort, having the opposite qualities, is reserved for thickening them when they run too freely. Oil of turpentine, which has been some time in store, is more generally used in England, and is said to answer the purpose better than any other volatile fluid.

It was remarked by Brongniart, whose practical knowledge qualified him to judge correctly on the subject, that of all the processes for painting on glass and porcelain described in works that were in existence at the time his essay was published, there was not one, by strictly following which, the desired colors could be produced. In describing these processes, one author had followed another without knowledge or examination; and even the treatise by Leviel, which forms part of the voluminous work on arts and manufactures, published under the auspices of the Academy of Sciences in Paris, is not free from this reproach. Such want of correctness, from whatever cause it may have arisen, is little honorable to the authors, who if even unable, by penetrating the veil of mystery wherein the manufacturers shrouded their practices, to expose them correctly to the world, might, without difficulty, have ascertained the truth or falsehood of that to which they were affixing the stamp of their authority. The course which they pursued would assuredly fail of success in the present day, when an acquaintance with chemical phenomena is no longer confined, as it formerly was, to a few among the rarer order of students, and such errors would be certain of confutation at the moment of their promulgation.

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Purple and *violet* colors are procured by dissolving gold in aqua regia (nitro-muriatic acid), and immersing a bar of pure tin in the solution. The product thus obtained is called, from its inventor, the purple precipitate of Cassius, and is used very generally for giving the above-mentioned colors to porcelain. A preferable way of preparing this precipitate is to dissolve the two metals separately, and by then bringing the solutions together in different proportions, various shades of carmine, violet, and purple are obtained. The first of these three tints is seldom used in porcelain works, for although extremely beautiful, it is also very transient, and may be easily spoilt by a small excess of heat, or by the contact of carbonaceous vapors, a circumstance which is the less important, as its place may be well supplied by a rose color obtained from iron, and which is not liable to the same disadvantage. Carmine color, when used for tender porcelain, is prepared with fulminating gold (made by dissolving the metal with aqua regia and precipitating with ammonia), and muriate of silver. This compound is without any addition of tin, which shows that an union of the oxide of tin with that of gold is not necessary—as many have supposed—for the production of purple.

Violet color is also made with the purple oxide of gold, requiring the presence of some portion of lead in the flux for the development of this shade. These three colors cannot bear exposure to the full heat of a porcelain furnace, in which they would wholly disappear. In using the precipitate of gold, it is mixed with about six times its own weight of flux, and is employed without previously fusing the two bodies together. When first applied on the porcelain, it is of a dirty violet color, but by exposure to heat this passes to a most beautiful purple. It is recommended to employ charcoal as fuel in baking this color. Frequent exposure to the fire will materially impair its beauty.

Red oxide of iron, prepared by the united action of fire and nitric acid (the aquafortis of commerce) yields a *red* color, which, although beautiful, is less brilliant than that produced from gold. As already stated, it is, however, preferable on account of its less liability to change. Shades of red, deepening from rose color, and passing by the increased application of heat to brown, are obtained from iron. The flux employed with this oxide is composed of vitrified borax, sand, and a small proportion of red lead, and the color may be used either with or without previous fusion with its flux. By the mixture of black and red oxides of iron, in different proportions, various shades of reddish brown, chestnut, &c. are obtained. Red colors produced from iron cannot be used on tender porcelain, since they

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disappear, in that case, on exposure to heat. This effect must be ascribed to the presence of lead in the glaze. Several experiments, conducted by M. Brongniart, have proved this fact beyond all controversy.

A very permanent red color is procured by calcining the oxide of iron with double its own weight of common salt (chloride of sodium). The processes used for this purpose must be carefully conducted, and the salt purified and decrepitated—that is, subjected to the action of heat until all crackling noise has ceased. The oxide is procured by dissolving iron filings in nitric acid, and precipitating with salt of tartar (subcarbonate of potass). The precipitate must then be placed on a thin sheet of iron, and exposed under a muffle to the heat of a charcoal fire, until it has taken a fine red color. The two substances having been well triturated together in a glass or porcelain mortar, are then calcined in a crucible, and the operation should be carried as far as possible, without occasioning the vitrification of the mass. When taken from the fire and cooled, the compound is again triturated; successive portions of hot water are poured upon it, stirred, and then removed, until the water is no longer colored. The fluid thus tinged is allowed to settle, and is, when clear, poured from the sediment, which is then washed five or six times in fresh portions of clear water.

To obtain *yellow* colors, for both hard and tender porcelain, white oxide of antimony, mixed with sand and oxide of lead, are employed, the latter substance serving as a flux to the others. Great carefulness is required in the preparation, as the lead frequently approaches, by reason of the heat, to a metallic state, and, in that case, appears in the form of black spots on the wares. Oxide of tin is sometimes added, and when the color is required to be livelier, and approaching to that of saffron, red oxide of iron is added, the too great redness of this being subdued by the action of the lead, in the fusion which the ingredients undergo, previous to their application on the porcelain. The colors thus produced are not susceptible of change, but if exposed to the full heat of a porcelain furnace would be entirely dissipated.

Oxide of uranium, mixed with oxide of lead, produces a straw color. By decomposing chromate of potass, with nitrate of lead, which is a saturated solution of lead in nitric acid, chromate of lead is precipitated, and this proves a very excellent yellow color.

Naples yellow is composed of 24 parts of ceruse, 4 parts of oxide of antimony, and one part each of alum and sal ammoniac (muriate of ammonia), calcined together at a moderate heat

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during three hours. The shade is varied by increasing or diminishing the proportion of sal ammoniac. The quantity of flux that must be combined with this color for use is uncertain, and must be matter for experiment with the manufacturer.

For the production of *blue*, well prepared and very pure oxide of cobalt is employed, mixed with a flux. Oxides of tin and of zinc, added in different proportions, give different shades, from a deep rich color to a light blue. As the oxide of cobalt is volatilized at a high heat, it is impossible to place in the same case, white pieces, and such as are painted blue; since the former would certainly assume a bluish tint in the operation of baking. This difficulty does not occur with tender porcelain, on which the cobalt is not volatilized as in the other case, owing to the heat being very inferior to that used in baking hard porcelain. These blue colors, if they have been previously fused, do not change at all after their application. The rich smalt, known under the name of azure-blue, is only the glass of cobalt, mixed with sand. This color must be fused in a crucible, and reduced to an impalpable powder in an agate mortar, after which it may be used in combination with flux.

Prussian blue, which results from the union of hydrocyanic acid with oxide of iron, is very extensively used in the arts; and being prepared on a large scale for sale, in various parts of the kingdom, no manufacturer of porcelain will undergo the trouble, or encounter the unpleasant circumstances attendant upon its preparation, but will rather obtain the comparatively small quantity he may require by purchase.

Green oxide of copper is usually employed for the production of a green color. On precipitating in different vessels, by means of potass, solutions of copper which are equally pure and concentrated, it is perceptible that the precipitate is formed more quickly in some vessels than in others; and if these different products are separately collected, those which are most promptly formed are, when dried, of a fine bright green, and produce a corresponding color on porcelain; while those precipitates which are deposited more slowly, form earthy and less dense particles of a much darker hue, and which, when applied to porcelain, yield a less pleasing color, and pass sometimes to black during the baking. If, however, the precipitated oxide is previously fused with its flux, this change need not be apprehended. Very pure oxide of copper is frequently procured by placing sheets of the metal in the oven wherein the ware is glazed. Mixtures of yellow and blue are sometimes used in the composition of green colors: some of these will not exist in the heat of a porcelain furnace. Various shades of beautiful green may be obtained, by mixing, in different proportions, Prussian blue

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with the chromate of lead already described. A mixture of the oxides of cobalt and nickel, will resist a very intense heat, but does not produce a genuine green: it is rather an olive color.

Oxide of chromium gives a beautiful green color, which is indestructible in the heat of a porcelain furnace. That class of green colors, called celestial blues, can only be applied, according to Brongniart, on tender wares: being partly composed of potass, they scale off from hard porcelain.

Different shades of light and of deep rich brown are obtained from mixtures of the oxides of iron. These must be fused with thin flux before they are used, after which fusion they do not undergo any change on the application of heat. Russet grounds, known under the designation of tortoise-shell, are produced in this manner. Felspar is employed as a flux with these colors.

There is not any metallic oxide which alone will give a good black. Oxide of manganese approaches the nearest to it. The black oxide of iron yields a very dull color, which sometimes changes to red. The color-makers therefore unite several oxides together, and thence obtain a very beautiful black. The oxides thus combined are of manganese, the brown oxide of copper, and a small proportion of the oxide of cobalt. A gray color is obtained by omitting the copper, and increasing the proportionate quantity of the flux.

Cobalt, oxide of copper, and umber, in equal parts, reduced together to an impalpable powder in an agate mortar, prove a very good black. This must be used with three times its weight of flux. Another black is composed of four parts oxide of copper, one part of smalt, and one part of black oxide of iron, which, like the former compound, must be rubbed together to a fine powder, and used with three parts of flux.

In the "Annales de Chimie et de Physique," (Vol. 20. 1822), directions are given for the preparation of a beautiful black enamel, the verification of which on the part of our porcelain manufacturers is perhaps desirable. The experiment necessary for this purpose might have been somewhat simplified, if the artist by whom the directions are communicated had stated the proportions wherein the ingredients should be brought together. The formula directs that chloride of platina, dissolved in water, should be mixed with nitrate of mercury. By then subjecting the precipitate which will be formed to a heat just sufficient to volatilize the proto-chloride of mercury, a black powder will be obtained. This is the enamel, which must be applied in the usual manner, in combination with a fluxing material.

M. de Montamy in his treatise, to which allusion has already been made, gives a *recipe* for composing a pure white color,

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which is found very serviceable by the French artists in forming their series of shades, as well as in the composition of those parts of their designs which require to be represented in a brilliant white. This color is composed of one part of virgin tin, and two parts of common salt. The latter must be thoroughly purified, by first dissolving it in distilled water, then filtering the solution through paper, and afterwards evaporating it to dryness over the fire in a porcelain capsule. The salt, which is, by this means, made extremely white, must be further exposed to heat in a crucible, until all decrepitating noise has ceased. The purification will be yet more perfect, if, after filtering it, the solution is partially evaporated, and then placed in a cool situation to crystallize slowly. Those artists who are the most particular in their processes, select preferably from the rest such crystals as take the form of cubes. The next part of the process is to place a crucible on the fire, well covered, to prevent the entrance of smoke or ashes. When this crucible is at a red heat, the tin is introduced, and is left until it is not only fused, but red-hot, at which time the purified salt is added in the proportion already mentioned. Taking then a clean iron spatula, the end of which must be previously heated, the mixture is stirred until the substances are well incorporated together. The crucible being then again covered, is to be surrounded with burning charcoal, and from time to time, the spatula, which must be always perfectly clean and hot, should be introduced to agitate the mass. When the end of this spatula, in being tempered by the heat of the crucible, begins to grow white, it is a sign that the calcination is carried sufficiently far, and that the crucible should be removed from the fire; the calcination usually occupies an hour for its completion. The compound should next be bruised in a mortar of glass or of agate, and again placed in a crucible which is set in the midst of burning coals and covered with a muffle. The heat is then raised gradually, and continued during three hours, when, on removing the crucible from the fire, the color is found to be hard, and requires some force to detach it from the vessel. This done, it must be pounded in a mortar, and washed in hot water that has been filtered or distilled, and fresh portions of water added, until the fluid has no longer any taste of salt. The white color is afterwards to be boiled violently with an abundance of water in an earthenware vessel for two hours, supplying hot water during that time to replace the portion that is evaporated. When the supernatant water has become clear by standing, it must be poured off carefully.

This white may be advantageously employed in painting with oil, as it mixes well with it. When used on porcelain, it must

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be mixed with three times its weight of flux. The preparation of this color will not succeed unless the tin is extremely pure, and it is essential that the nicest possible degree of cleanliness should be observed throughout the operations.

By making different mixtures of the various colors here described, every hue that can be desired may be obtained. It is not, however, so easy, as without due consideration it might appear, to produce these various shades. Great judgment in the selection of materials, carefulness in their preparation, and knowledge as to the relative proportions wherein they should be brought together, are essential to success; and an acquaintance with the science of chemistry is highly desirable. There are some colors which, if mixed, would mutually destroy each other, and on the exposure of metallic oxides to heat, changes ensue, which result not from the nature and habitudes of the colors themselves, but rather from the influence of the bodies to which they are applied.

It would be scarcely possible to treat satisfactorily upon the inciting causes of all these variations, a full knowledge of which can result alone from the practical experience of the artist and manufacturer.

Many potters do not prepare their own enamel colors, but purchase what they require from persons who manufacture them for sale. Some of these preparations are exceeding costly, and as the temptation to adulterate them is consequently great, the potter should have good reason to rely on the probity of the color-maker with whom he deals. A fraudulent mixture, the detection of which would be impossible before its use, except by means of a chemical analysis, might be the occasion, in its results, of severe loss and disappointment. With the exception of the great works at Sèvres, this system of purchasing their enamel colors has, for many years past, been very general among the potters of France. In a report made to the French government, by a commission appointed in 1819, to examine into the progress of manufacturing industry in that country, occasion was taken for offering congratulations upon this establishment of an independent occupation, as marking the great extension of the porcelain manufacture, and as offering to the artist means of obtaining every shade of color, prepared by persons whose interest is involved in ascertaining their effects when submitted to the heat of the furnace, thus removing all uncertainty from the operations of the painter, and rendering it unnecessary for him to suspend his work that he may prepare his colors.

The gold used in gilding porcelain is applied in a metallic state. To prepare it for this purpose, it is dissolved in aqua

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regia, and the acid being afterwards dissipated by the application of heat, the gold remains in the state of powder at the bottom of the vessel. This powder must be mixed with borax and gum-water, as a vehicle for causing it to flow from the pencil and fix upon the wares; which being then baked, the gilding appears void of lustre, and requires to be afterwards burnished with either agate or blood-stone.

Gold and silver *lustre-ware* is commonly of an inferior quality. The metallic oxides used for covering these vessels are intimately mixed with some essential oil, and then brushed entirely over their surfaces. The heat of the enamelling oven, which dissipates the oxygen, restores the oxides to their metallic state, but with some diminution of brilliancy. The oxide of platinum is used for making silver-lustre.

Colors, when they are required for use, should be first pounded quickly in a mortar made of either agate, porcelain, or glass, with a pestle of the same material, and covered to prevent the access of dust. They must be afterwards ground on a glazed palette, firmly bedded in plaster on a wooden frame, and perfectly level. The artist who decorates porcelain is required to rub his colors with as much nicety as is used by miniature painters, so that there must not remain the least perceptible roughness, either under the muller or between the fingers. The requisite proportions of volatile oil and of flux are added and ground with the colors on the palette, the whole having been carefully weighed before their union. The general rule is to put five parts of flux to two parts of coloring matter: but some colors, as already mentioned, require more, while with others this proportion would be too great. Smalt requires to have combined with it only half the sum of its own weight.

The artist must be attentive to grind his colors with the smallest quantity of oil that will suffice; if this should be in excess, it may in evaporating leave spaces between the particles of color, and the subject would appear very imperfectly executed. The fluidity of the mixture should be kept at that exact point which enables the artist to produce the finest strokes with clearness and facility.

Before the pieces which have been painted are baked in the enamelling-kiln, it is necessary to dry the colors by evaporating the oil used with them as the vehicle.

Every considerable pottery has enamelling-kilns of various sizes. These are in form like a chemist's muffle, from about six to ten feet long, and from three to five feet wide. The articles are piled in the kiln until it is filled, when the mouth being closed, fire is applied, and continued for about eight or ten hours, at the end of which time the colors are found to be burnt

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into the glaze. In piling the pieces in the kiln, care must be used to avoid the placing of any one piece upon the gilt border of another. The muffle is provided with trial pieces, which can be extracted from time to time during the baking, and which will indicate the general state of the contents of the kiln, so as to govern the continuance of the operation. No delay should occur between the sufficient baking of the colors, and the withdrawing of the fire, as their brilliancy would be injured by its longer continuance. The contents of the kiln are left undisturbed until they are cool, and are then withdrawn. All impure exhalations are prejudicial to the beauty of colors, and every substance whence they can arise should, as far as possible, be kept away from the kiln during the process.

Gilding on porcelain or on glass is performed either with or without the addition of a fluxing material, the gold being made to adhere to the surface by the incipient fusion of either the glazing on the porcelain, or of the surface of the glass, or of the flux employed.

Gold is used for this purpose sometimes in the form of leaf gold, and at other times in that of powder, prepared either mechanically, or by chemical precipitation. When the first of these two methods is employed, leaf gold must be ground with honey or with gum-water of an equal consistence; the honey or gum being afterwards washed away, the gold may be kept for use in paper or in shells, and the use of these latter recipients has occasioned this powder to be known among artists as "shell gold." This precious metal is precipitated from its solution in aqua regia, by adding to it a watery dilution of green vitriol (proto-sulphate of iron) or strips of metallic copper. Gold powder may likewise be obtained from the same solution by distilling it to dryness; but this process is not so convenient as precipitation. The powder has also been procured by first forming an amalgam of the metal with mercury, and then evaporating the latter; but besides being expensive, the fumes of mercury are found to be extremely prejudicial to the health of the operators.

When gold powder is used, it must be mixed with gum-water as a vehicle. Where it is intended to apply leaf gold without any fluxing material to the body of the wares, these should be moistened in the requisite parts with a weak solution of gum-arabic, which must afterwards be allowed to dry. When the gold is applied, the porcelain or glass may be made sufficiently adhesive by breathing on it. If a flux is employed, it should, after being rubbed very fine with a muller, be diluted with weak gum-water, and very thinly spread over the parts which it is designed to ornament; when very nearly dry, the leaf gold is laid upon it.

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Japanners' gold size, moistened to the requisite degree with oil of turpentine, is sometimes employed. Waiting then until the size is so far dried as to be only clammy to the touch, the gold leaf is laid on with cotton wool. As soon as the gold is applied, the ware is placed in an oven or muffle, that it may be burnt on.

Some old authors direct the artist to fuse gold with regulus of antimony, to pulverize the mass, and to spread the powder upon the parts to be gilded, exposing the ware afterwards to such a heat as will suffice to evaporate the antimony, while the gold remains fixed. This method of proceeding is objectionable, from the almost impossibility of spreading the powder in a sufficiently uniform manner, besides which, part of the gold will also be carried off, and some descriptions of glass are even fusible with the degree of heat necessary for perfecting the process.

Circular gold lines are frequently described on small articles, such as cups, saucers, and plates. To assist him in tracing these with accuracy, the artist employs a portable horizontal wheel, the height of which may be adjusted at pleasure, according as the nature of the work requires it to be performed in a standing or a sitting posture. The lower part of this wheel is somewhat similar to the leg and feet of a claw table, the leg being bored out for the reception of a stout metallic wire, the altitude of which is regulated by means of a thumb-screw.

The upper or movable part of the wheel has a like tubular cavity in its vertical part, by means of which it is dropt on to the upright wire, and is made to rest upon a shoulder fixed on the wire, so that the wheel may be made to turn truly upon this as its axis: the whole is surmounted by a horizontal table.

In proceeding to use this machine, the artist places his feet firmly upon the base of the wheel, and fixing the article to be ornamented upon the table, he causes the revolution of the wheel with his left hand, and holding his brush steadily in the other, describes the circles with the utmost facility and accuracy.

Burnishing, which is the last process performed in the manufacture of ornamented porcelain, is usually intrusted to female hands. The implements required for this purpose are, a burnisher of agate or blood-stone, some white lead, a piece of sheepskin for wiping the ware, and some vinegar. As extreme cleanliness is indispensable, the person engaged in burnishing does not even touch either the porcelain or her implements, but interposes between them and her hands a piece of clean white linen. The agate burnisher should be applied lightly on the gilding, following all the ornaments, and never rubbing in cross directions, lest the gilding should appear scratched.

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After having rubbed the gilding for some time, a little vinegar or white lead should be applied to cleanse the surface. This being removed with a soft linen rag, the burnishing is recommenced, and continued until the gilding throughout assumes a satisfactory appearance.

It will be remembered, that in the preceding description of the colors used in painting porcelain, several were mentioned as being unable to support the heat of the gloss-oven. Others, however, have not this disadvantage, and will bear the highest temperature without injury. Where colors are applied directly on the biscuit, no oil is ever ground with them, but they are mixed with water only, and the glaze may be added without any intervening application of heat. The temperature of the enamel-kiln is usually about six degrees of Wedgwood's pyrometer, answering to 1857 degrees of Fahrenheit's scale.

In the year 1817, the Society for the Encouragement of Arts, &c., awarded a premium to Mr. R. Wynn, for a list of receipts communicated by him, for the preparation of enamel colors and fluxes. A copy of Mr. Wynn's paper is inserted in the 35th volume of the Transactions of that Society.

The fluxes are,	No. 1.	Red lead . . . . . 8 parts.
		Calcined borax . . $1\frac{1}{2}$
		Flint powder . . . 2
		Flint glass 6
	No. 2.	Flint glass 10
		White arsenic . . . 1
		Nitre 1
	No. 3.	Red lead 1
		Flint glass 3
	No. 4.	Red lead . . . . . $9\frac{1}{2}$
		Borax, not calcined $5\frac{1}{2}$
		Flint glass 8
	No. 5.	Flint glass 6
		Flux, No. 2. 4
		Red lead 8

The ingredients forming each of these fluxes are melted together, and the compounds are then finely pounded for use.

The recipes for colors are as follows:—

Yellow.	Red lead	8 parts.
	Oxide of antimony	1
	White oxide of tin	1

Mix the ingredients well in a biscuit-ware mortar, and having put them on a piece of Dutch tile in the muffle, make it gradually red-hot, and suffer it to cool. Take of this mixture 1 part; of flux, No. 4, $1\frac{1}{2}$. Grind them in water for use. By varying

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the proportion of red-lead and antimony, different shades of color may be obtained.

Orange.	Red lead	12 parts.
	Red sulphate of iron . . .	1
	Oxide of antimony	4
	Flint powder	3

after calcining these without melting, fuse one part of the compound with 2½ parts of flux.

Dark-red.	Sulphate of iron, calcined dark . .	1 part.
	Flux, No. 4. . 6 parts Colcothar . . 1 } of this . .	3
Light-red.	Red sulphate of iron, . .	1 part.
	Flux, No. 1.	3
	White lead	1½
Brown.	Manganese	2½
	Red lead	8½
	Flint powder	4

The style of decoration described in the preceding pages of this chapter, is in a great measure confined to the most costly descriptions of porcelain. Wares which are fitted by their price for being brought into more general use, undergo a different kind of embellishment. A great variety of neatly executed patterns are transferred to their surfaces from impressions previously printed on paper. Before the introduction of this style of ornament, table services of home manufacture were either composed of plain Queen's-ware, with occasionally a colored edge; or at best were furnished with a painted border, which displayed but little taste in its conception, or ability in its execution. This modern improvement has added materially to the decent comforts of the middle classes in England, and has more than any other circumstance contributed to the great extension of our trade in earthenware with the continent of Europe. When first invented, and for some time afterwards, the designs employed were only imitations of figures and objects seen on old blue China porcelain; but a better taste has since prevailed, and artists employed in the composition of patterns no longer think it necessary to outrage truth in their representations. Landscapes and figures, in conformity with the simplicity of nature, and exhibiting a considerable degree of taste, are now so common, that this new advantage derived from the printing-press is enjoyed without exciting attention or commanding acknowledgment.

The method of transferring printed designs to earthern vessels is thus pursued. The landscape or pattern is engraved upon copper, and the color, which is mixed with boiled linseed oil, is laid on the plate in the same manner as ink is usually

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applied by copper-plate printers. To increase the fluidity of the oil, the plate is then temporarily placed in a stove, a sheet of damped tissue paper is laid on it, and both are passed in the ordinary manner through the press. The paper, wet with the color, is then delivered to a girl, who reduces its size by cutting away the blank portion surrounding the pattern, and passes it to another girl, by whom the impression is applied lightly to the ware when in the state of biscuit. A third girl is next employed, who, with a piece of woollen cloth rolled tightly in the form of a cylinder, rubs the paper closely against the piece, in order to press the color sufficiently into its substance. The paper thus rubbed is left adhering to the article for an hour, when both are placed in a cistern of water, so that the paper becomes soft enough to be peeled off without violence, having transferred to the biscuit the impression which it had received from the copper-plate.

When the pieces thus printed have stood a sufficiently long time to become dry, they are placed in an oven, to which a gentle heat is applied, in order, by dissipating the oil, to prepare the wares for receiving the glaze. This is, of course, completely transparent, as otherwise the distinctness of the pattern would be impaired.

For a long time blue, produced from the oxide of cobalt, was the only color employed; but, of late, the potters have extended to this pleasing branch of their art all the colors on their palette.

The glaze on printed goods is vitrified in the gloss-oven in the manner already described.

The French potters employ a different method for transferring engraved patterns. They cast a sheet of fine glue, about a quarter of an inch thick, and diluted while warm to such a degree that when cool it shall be perfectly flexible, and have the consistence of leather. This glue being applied upon the plate, and pressed with the hand, receives the colors according to the pattern, which it gives back to the surface of any vessel to which it may be applied. Two impressions may generally be given in this manner without a fresh application of the glue to the plate. After the second has been impressed, the surface of the glue is cleaned carefully with water applied by a soft brush, and serves again as before.

The decoration of earthenware by means of engravings is of much more recent adoption in France than in England,—not having been used in the former country until about the year 1805.

In the report made by the Committee appointed to examine into the progress of the arts and manufactures in France, as

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exemplified by specimens exhibited at the Louvre in 1819, and to which report allusion has already been made in this Chapter, attention is drawn to a curious process, whereby a porcelain manufacturer was enabled, on being furnished with an engraved copper-plate, to produce impressions on any scale that might be required, whether larger or smaller than the original. For this purpose no second plate of copper was needed; and the enlarged or diminished copies might be furnished in the course of a very few hours. It is to be regretted that no description was given of the means employed for effecting this curious process; but the Committee, who personally witnessed its execution, expressed themselves perfectly satisfied as to its efficiency, and awarded an honorary gold medal to the inventor.*

CHAP. VII.

ON THE MANUFACTURE OF TOBACCO PIPES.

This Manufacture prosecuted to a great extent.—Description of Material.—Rolling.—Boring.—Moulding.—Polishing.—Baking.—Description of Kiln.—Of Crucibles.—Manufacture in Holland.—Originally conveyed there from England.

THE manufacture of tobacco pipes forms a branch of the potter's art, which has acquired considerable importance from the extent to which it is prosecuted; and it is at the same time interesting from the nature of the processes employed. A short account of these will, therefore, not be thought misplaced in this treatise.

The clay chiefly employed for the purpose is found in the island of Purbeck, in Dorsetshire, and is preferred on account of its extreme whiteness. Previously to being used, it must be diligently purified from all extraneous matters. The means employed for this latter purpose, being the same as have already been described, their recital may be omitted here.

When the purification is accomplished, and the clay has been formed into cubical masses, weighing each from eighty to one hundred pounds, the workman from time to time cuts off small portions, each sufficient to form one pipe, and, first kneading them thoroughly upon a table, rolls them out to nearly the form and size of pipes, leaving a bulb at the end for the formation of the bowl. In this operation, the skill of the man is made apparent by the near approach which this roll makes to the dimensions actually required. Persons who have had a

* Ann. de Chim. et de Phys. tom. xiii. p. 94.

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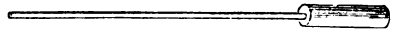
competent experience will succeed in this respect to such a point as completely to fill the mould, to which the rolls must afterwards be transferred, leaving but little surplus clay to clip away.

Fig. 5.

When the rolls have been formed for a short time, and by that means have become sufficiently hardened, the workman proceeds to bore the stem by introducing an iron needle. This part of the manufacture calls for a great deal of address, and

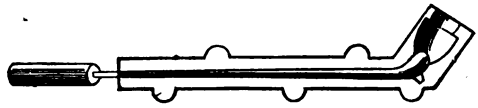
Fig. 6.



can only be satisfactorily accomplished after long practice. In performing it, the roll is taken between two fingers, which follow the point of the needle in its course through the whole length of the stem. Near to its point the needle has a circular enlargement, the progress of which may be felt through the substance of the clay; and thus the execution of the task is somewhat facilitated. The bore must be made as exactly as possible in the axis of the stem; and, in forming it, the needle must be pushed forward by means of its wooden handle, with a gentle and equable pressure. The part which is to form the head or bowl of the pipe is then bent so as to give it the proper inclination.

The mould, into which the stem is next placed, is of copper, and divided into two similar parts. On being put to use, the

Fig. 7.



whole interior surface of both sections must be slightly touched with a brush containing some very limpid oil, that the stem may be afterwards delivered from it without difficulty. The roll of clay being placed in one section, the other is fitted to it according to marks previously made, so as to insure the perfect correspondence of the two parts. The mould is then subjected to the action of a small iron press, in which the two parts

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are forced together by means of nuts and screws; and by this means its exterior form, with all its ornaments, is at once given to the pipe.

The head or bowl has yet to be fashioned. This is in part effected by the fore-finger, and more perfectly thereafter by means of a stamp or form attached to the mould, and which by the action of a lever is introduced within the hollow which the finger has made for the purpose. The bore of the stem is then continued into the bowl, by pushing the needle up to its handle; any excessive quantity of clay that may have been used is next cut away, and the pipe is smoothed by means of an iron or copper blade.

The pipes as they are formed are spread out and arranged upon a board, that they may be still further dried; and when they have acquired a certain consistence, any roughnesses that may appear upon the bowl are rubbed away with an appropriate horn instrument, which is provided with a groove, of which the workman avails himself to perfect the circular form and to smooth the edge of the bowl.

After this the pipes are placed a second time in the moulds, that any imperfections which they have acquired in their shape may be remedied; and they are then left until sufficiently hardened to receive the last polish, which is given by rubbing them with flints bored with holes, some of which are of the same diameter as the stem, while others will admit the head of the pipe. If it should then appear necessary, the workman retouches the different ornaments on the pipe with a kind of bodkin, and the needle is withdrawn from the stem.

These various operations, which bear an appearance of complexity in the narration, are yet so easy of accomplishment, that a clever moulder will furnish 3500 pipes in a week.

The kiln used for baking the pipes is cylindrical; having a circular fireplace at its bottom. With the exception of the spaces required for the circulation of heated air, the interior of the kiln is occupied by crucibles, wherein the pipes are placed. These crucibles, which are made very thin, are composed of the same clay as the pipes, and are strengthened by the insertion of broken pipe-stems. The bottoms are framed of these stems, radiating towards the centre, and having the interstices plastered with pipe clay. The top of each is dome-shaped; and a pillar of clay is placed in the centre through the whole altitude, which serves at once to strengthen the crucible, and to support the stems of the pipes. The side of the crucible is provided with six horizontal ledges, proceeding at equal distances all round, and upon these the bowls of the pipes are arranged, while the stems are made to lean against the central

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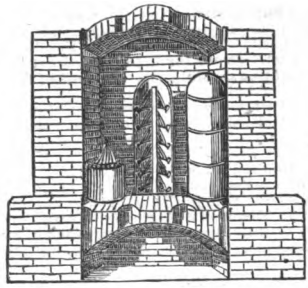
pillar. The crucible is capable of containing in these six divisions fifty gross of pipes; and, if the heat of the furnace is properly managed, these will be sufficiently baked in seven or eight hours.

Fig. 8



The property possessed by tobacco pipes of adhesiveness to the tongue, is owing to the great affinity which the clay has for water: this quality is much increased by the baking process.

The manufacture of tobacco pipes is prosecuted to a very considerable extent in Holland, whence large quantities have long been exported annually. For the introduction of this art the Dutch are indebted to this country; in proof of which assertion, Mr. Hollis, who passed through the Netherlands in 1748, mentions that, having visited very extensive pipe-works at Gouda, he was informed by the master of it, that even to that day their principal working tools bore English names.

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CHAP. VIII.

ON THE PORCELAIN MANUFACTURE OF CHINA.

Obscurity wherein its Origin is shrouded.—Chiefly practised at King-te-Ching.—Supposed Superiority of Old China Ware.—Materials employed.—Kao-lin—Pe-tun-tse—Their Preparation.—Oils or Varnishes—Their Composition.—Hao-che—Its Superiority to Kao-lin.—Analysis of Kao-lin.—Extent of Factories at King-te-Ching.—Great Number of Workmen employed.—Preparation of Materials.—Method of fashioning Utensils.—Moulds.—Division of Labor.—Deficiency of Chinese in the Art of Design.—Their Excellent Colors.—Numerous Hands employed in Decorating each Piece.—Bad Effect of this System.—Blue long the only Color used for Painting China Ware.—Mode of Preparing various Colors.—Chinese ignorant of Chemical Science.—Umiam.—Tsou-tchi.—Kia-tsing—Method of forming it.—Chinese Furnaces.—Passion for Old Porcelain.—Ku-tong.—Mock Antiquities.—Reasons for Costliness of China Ware in Europe.—High Prices formerly paid in China.—Finest Specimens not brought to Europe.—Porcelain Tower at Nan-king.—Chinese Potters prepare Materials for the Use of their Descendants.—Common Wares made in China.—Attempt of the Emperor to transfer the Manufacture to Pekin.—His Want of Success.

No success has attended any efforts that have been made to discover the origin of the art of making porcelain in China, and the date of its invention remains veiled in obscurity. The most that is known on this head is gathered from the written annals of Feou-leang, a city belonging to the same district of the empire as King-te-ching, wherein it is recorded that, from the time answering to the year 442 of the Christian era, the last-mentioned place has enjoyed the honor of supplying the imperial court with porcelain, and that one or two mandarins have usually been deputed from Pekin to inspect this part of the workman's labors. The invention of the art would assuredly date from a much earlier period than that here mentioned; as it would be long ere the manufacture arrived at such a state of perfection as to render it an object of interest to the court.

It is a very common opinion in China, that the porcelain ware made by their ancestors was superior in quality to any more recently manufactured. This belief is grounded on the fact, that pieces of porcelain are frequently dug from the earth, which are uniformly found to be of the very finest description. It has been remarked, that this fact is not by any means conclusive evidence upon the subject; the buried pieces were most probably concealed, during periods of civil commotion, on account of their value, and in order to preserve them for their owners, who were without an equal inducement to bury articles of more common use. An opinion likewise prevails, and is supported by reference to the same fact, that the quality of porcelain vessels is improved in beauty by a lengthened burying

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in the earth; and the same answer has been applied to this as to the first-mentioned assertion.

The Chinese employ in the composition of their porcelain two kinds of earths, and two oils or varnishes. Of the earths one, which is called kao-lin, is found intermixed with particles of a shining substance resembling mica; the other is known by the name of pe-tun-tse, and is of a brilliant white, exceedingly fine in its grain, and soft to the touch. Both these descriptions of earths are found in mines or quarries situated between twenty and thirty leagues from King-te-ching, to which place they are brought in small vessels, which are continually passing up and down the river of Jao-tcheou for that purpose. The hard blocks of pe-tun-tse are cut from the quarry in the form and about the size of our bricks, and are brought in this state to King-te-ching. The first preparation which these lumps undergo, is that of breaking and pounding them coarsely with iron mallets, and afterwards more completely in mortars with pestles, wrought either by the hand or by a water-wheel. By this means the blocks of pe-tun-tse are reduced to an almost impalpaple powder, which is thrown into an urn-shaped vessel nearly filled with water, and then stirred briskly about, that the particles may be intimately mixed with the water. When this mixing has been effected, and the fluid has been left during a short time to repose, a white creamy substance forms upon the surface, to the depth of two or three inches: this, being skimmed off, is transferred to another vessel, supplied with clear water. The fluid remaining in the first vessel is then again stirred up; another portion forms upon the surface, which in its turn is removed, and added to the first skimming; and this process is continued as long as any creamy substance can be collected from the surface. What remains in the urn-shaped vessel has not been sufficiently ground; and, being collected from the bottom, must be again submitted to the process of grinding.

The skimmings are left to settle in the second vessel, until the solid portion has subsided to the bottom, leaving the supernatant water perfectly clear: this is then poured off; the sediment is transferred to moulds, wherein it remains until nearly dry; and the cakes are then taken out and cut into square pieces of the size most convenient for use. The pe-tun-tse is then in a fit state for combination with kao-lin; and the squares are sold by the hundred to the porcelain makers. It is not often that the manufacturer can venture upon using this material in the state wherein he buys it; the men who have been previously employed in preparing the cakes, most generally mix in the squares as large a portion of foreign matter as they expect

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will escape detection: a separation of these previously to the employment of the earth becomes, therefore, needful.

A similar process is followed in the preparation of kao-lin; but this substance being much less hard than pe-tun-tse, less labor is required for its performance.

The two substances described as oil or varnish are procured, one from a combination of pe-tun-tse with another mineral substance, and the other from lime. In the preparation of the first of these, such stones are preferably selected as have the whitest appearance. These undergo the same processes of grinding and washing as have already been described; except that the creamy substance, when it has subsided in the second vessel, is not all put into moulds, but only the upper and finer stratum is gathered for the preparation of this varnish. To each one hundred pounds of the substance thus separated one pound of a mineral called she-kao, which is a kind of gypsum, is added. This stone, which resembles alum in its appearance, is first raised in a furnace to a red heat; and then reduced, by pounding and rubbing in a mortar, to a very fine powder; in which state its union with the purified pe-tun-tse is effected, the consistence of the compound being perfectly fluid.

The preparation of what is called *oil of lime*, the fourth ingredient required, is thus managed:—Lumps of quicklime are first sprinkled with water, and reduced to a powder; upon this a bed of dried fern is placed; then another layer of lime, covered again by fern; and so on alternately, until the pile having reached a moderate height, fire is applied: and when the whole of the fern is consumed, the ashes are collected and strewn upon fresh beds of fern, which are again fired; and this burning process is repeated five, six, or more times successively,—it being held that the more frequently the ashes are burnt, the better is the quality of the product. Some ancient Chinese annals affirm that, instead of fern, the wood of a kind of medlar tree was anciently used; and that the quality of the porcelain was in consequence more beautiful. This wood is now become too scarce to be employed for the purpose. The lime and fern ashes are next thrown into a vessel containing fair water, and she-kao is added in the same proportion as to the creamy dilution of pe-tun-tse. This she-kao dissolves; and the solid matter being separated from the water by subsidence, and removed in a tolerably fluid state, forms what the Chinese manufacturers call the oil of lime, to the agency of which they attribute all the lustrous appearance of their porcelain. Lime, when uncombined, is infusible, except at a very intense degree of heat; and the fern ashes thus added, are essential, acting as a flux, and promoting the fusion of the glaze in the furnace. In mix-

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ing these two varnishes together, only one measure of the oil of lime is added to ten measures of that of pe-tun-tse, care being taken that the consistence of both is equal. The oil of lime is easily, and to the seller profitably, adulterated by the addition of water, combined with such a farther portion of she-kao as preserves its proper degree of consistency.

It is said that, since the time when D'Entrecolles communicated his observations on the porcelain manufacture in China, the potters there have discovered a new species of mineral, which can be advantageously used in the preparation of porcelain. This is a species of chalky stone, which bears some outward resemblance to soap, and is declared to possess considerable medicinal virtues. It is called hao-che; and when used instead of kao-lin, the result is porcelain of very fine grain, exceedingly light, and much better qualified for receiving colors, but more brittle, and far dearer in its cost, than the commoner kind of ware, the price of hao-che being three times that paid for kao-lin. This new substance, when taken from the mine, undergoes the operation of a careful washing, to separate from it a kind of yellow earth with which it is always found accompanied: it is then pounded, and treated exactly in a similar manner to that described in the preparation of kao-lin. It is affirmed that hao-che, thus purified, is capable of being made into porcelain without any admixture.

It is the kao-lin which, although much softer than the pe-tun-tse when taken from the quarry, gives strength and body to the porcelain; and, consequently, this, or some substitute possessing the same quality, forms an indispensable ingredient in its composition. It is related that some Europeans, having privately obtained some blocks of pe-tun-tse in China, and conveyed them to their own country, vainly endeavored to convert them into porcelain; which becoming known to some Chinese manufacturers, they deridingly remarked, "that certainly the Europeans must be a wonderful people, to go about to make a body whose flesh was to sustain itself without bones."

Kao-lin is known, from the particles of mica which it contains, to have its origin in felspar, or graphic granite. It is infusible with the heat of a porcelain furnace even in China, the degree of which must be most tremendous, as some of the materials employed in their glazes could not be vitrified at a lower temperature than would suffice to fuse Cornish granite. The kao-lin quarries of China agree with the mines of Alençon and St. Yrieux near Limoges, where a similar earth is found—all of them having a super-stratum of red, friable, micaceous rock, of the texture of gneiss. The constituent ingredients of kao-lin are found to be—silica 52, alumina 42, oxide of iron 0.33.

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The factories employed at King-te-ching for the porcelain manufacture are of great extent. They are walled round, and contain sheds under which the processes are carried on, as well as dwellings for the workmen. The number of people employed in one of these factories is very great, as must appear when it is considered that almost every piece of porcelain produced, however small, passes through more than sixty different hands before it reaches a state of perfectness.

When the purification of the two earths has been completed by the processes already described, the next operation is to unite them in the requisite proportions. The relative quantities of these materials depend upon the quality which it is desired to give to the porcelain.—For the finest kind, they mix the kao-lin and pe-tun-tse in equal quantities, and diminish the proportion of the former according as coarser kinds of ware are required; but, for the very coarsest descriptions, the kao-lin never forms less than one fourth of the mass.

The most laborious part of the whole operations of the factory, is that of intimately kneading and working the earths together, so as to form of the two one homogeneous mass. This is performed in pits, which are paved and cemented, wherein the workmen continually trample upon the paste, bringing together fresh portions by turning it over; and this work is continued without intermission, one set of workmen relieving another at intervals, as each becomes fatigued by the labor, until the mass is thought to be thoroughly mixed, and has been brought to a consistence proper for being moulded by the potter. The mixture is then removed from the pit; and being divided into small portions, is again kneaded with the hands upon large slates provided for the purpose. Too much careful industry can hardly be exercised in this operation. If the smallest drop of water or globule of air be left remaining in any portion of the mass, the article which contains that portion will infallibly be spoiled by the expansion of the fluid in the oven. The smallest grain of sand, or even a single hair, left in the paste, would be equally prejudicial, occasioning the porcelain to run, or crack, or warp in the baking.

The pieces are fashioned by the Chinese workmen in a manner so similar to that adopted in our own potteries, that it would be useless to narrate the process.

The moulds used in the potteries of China for forming pieces of multiform shape are made in several portions or divisions, which are brought together when used. They are made of a yellow unctuous earth, which occurs abundantly in quarries near to King-te-ching; and its preparation by kneading and beating is very similar to that bestowed on the porcelain earths. When

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made and used with care, these moulds will last for a long time. The Chinese workmen are not content with the work as delivered from the moulds, but uniformly finish the article by the hand, using a variety of chisels and other tools to touch up the various lines and forms given by the mould, as well as to supply its probable deficiencies; so that the potter executes, in some sort, the art of a sculptor. In works where different objects appear in relievo, these are made separately, and added in the way commonly used in our own potteries.

It may give some idea of the number of hands employed in the perfecting of every piece of porcelain to state what D'Entrecolles has related to occur with the commonest description of tea-cup. The potter has the management of the wheel; and under his hands the cup assumes its form, height, and diameter. It may be well imagined that this workman does not bestow much labor upon his task, when we are told that for fashioning twenty-six cups he receives a sum equivalent to about three farthings of our money: the cup, accordingly, is delivered by him in a very imperfect state to a second workman, who fits it to its base. From him it passes immediately to a third man, who, by means of a mould, placed on a kind of lathe, corrects the imperfections of its shape. A fourth man, by the aid of a chisel, corrects the inequalities and unevennesses of the edges, and pares the cup to a substance which renders it sufficiently transparent. In the course of this operation he has frequently recourse to water, in order by moistening to prevent the cracking or breaking of the cup. A fifth workman then smooths the inside by turning it gently on a mould. Considerable care is required in this stage to prevent any warping or the formation of any cavity in the cup. Other men then, according to the description of cup which it is intended to produce, add either the handle, or some ornaments in relievo, or make sunken impressions. The operation that immediately precedes the first baking of the cup, is that of rounding and hollowing the inside of its foot: this is performed with a chisel.

By this division of labor, the work is found to proceed with greater regularity and rapidity. Incessant attention to one operation, and that of a very simple kind, gives to each workman considerable dexterity and facility in its performance; and no time is lost in the changing of implements, as must be the case if one man had to conduct the manufacture through its several stages.

Very large pieces of porcelain are made at King-te-ching. These are sometimes of such magnitude, that they must first be formed in two, three, or more sections; each one of which requires to be supported during its formation by three, or more

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men. When the different portions are sufficiently dry, they are united together with slip, in the same manner as handles are attached; and the seams are smoothed and polished with an iron instrument, so that, upon their being afterwards covered with varnish, it is not possible to discern the points of junction.

The celebrated traveller Marco Polo mentions the vast extent to which the manufacture was carried at the time of his residence in the Celestial Empire, and states that eight porcelain cups might then be purchased at the low price of a Venetian groat.*

Among the Chinese, the art of design has never advanced beyond the very first steps. These people appear ignorant of the commonest rules of perspective; and their drawing, especially where attempts are made to describe the human figure, is wretched in the extreme. To make some amends for this, the colors which they employ are exceedingly lively and brilliant, so that European artists have found it a difficult task to vie with them in this respect. In examining the painted porcelain of this singular people, one is almost led to imagine that their artists have been debarred the sight of the objects which they attempt to represent, as otherwise some among them must surely have possessed sufficient innate taste to have led him from the general track, and instead of the miserable caricatures that disgrace their labors, to have made some approach towards the truth in his delineation of natural objects.

The system of distributing the work among a great number of hands, which is found so successful in the formation of porcelain, is also pursued in the painting department. One artist forms only colored circles about the edges; another traces flowers, which a third paints; a fourth delineates nothing but mountains; a fifth describes water; a sixth traces the outline of birds, which a seventh fills up with colors. Other artists trace and color animals; others again perform the same tasks with the human figure, and in this way every object of art and nature found upon their porcelain is the work of a particular artist, who does not attempt the delineation of any other subject. To this system, so useful in conducting every merely mechanical operation, may possibly be owing the continued adherence to old and faulty methods. The celerity which it is calculated to produce is unfriendly to the improvements suggested by genius; and if even one artist among the crowd should be found with taste enough to aim at forming and embodying juster conceptions, his approaches to nature would only

* Marsden's translation, 4to edition, page 560.

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serve to render more glaring the deformities produced by his fellow-laborers, and would, therefore, be wholly inadmissible.

It is said, that for many ages the Chinese used only white porcelain. Tradition adds, that its whiteness was most brilliant, that the pieces were altogether faultless, and that the only name by which they were known when exported to other kingdoms was that of "the precious jewels of jao tcheou." Blue was the first color wherewith they ornamented pottery, but the employment of all other colors very speedily followed upon the introduction of this one. At first, and for a long time, their blue color was prepared from a very fine kind of lapis lazuli, which is native with them; but they now import smalt from England, at a price so much below that which their own pigment had cost, that they have abandoned its manufacture, and depend upon their foreign supply. The fine deep-blue sometimes found upon specimens of old Chinese porcelain is much admired and valued by *virtuosi*, and it is regretted that this color is not used at present. It has been conjectured that the Chinese, who unquestionably possess cobalt, most probably employed its oxide also in the production of this esteemed blue color before they were enabled by their commerce with Europeans to substitute for it our cheaper pigment; that their method of preparing the ore of cobalt was such, that it retained the arsenic with which it is always found in combination, and that, consequently, its color proved much deeper and richer than the preparation made by us from the same mineral. Our process being performed in a reverberatory furnace, the arsenic is driven off in fumes. There are some kinds of cobalt which are made to yield smalt without this previous roasting, and the superior color which in such case is always produced is attributed to the presence of arsenic; since if this mineral be added to smalt while in a state of fusion, the color will be rendered much deeper. The preparation of smalt from cobalt without the aid of fire is more expensive and the produce less in quantity than where the common process is followed. The French manufacturers procure their smalt by dissolving cobalt in nitric acid (the aqua fortis of commerce), and then precipitating; and it might be well for our porcelain makers to try the effect of this method.

The red color used by the Chinese is made from common green vitriol or copperas (proto-sulphate of iron), which goes with them by the name of tsa-fan. This material they calcine in a crucible, continuing to apply fire for so long a time as thick black fumes are seen to escape from a hole made in the top of the crucible; but when these fumes are succeeded by a

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light and thin cloud, they judge that the process has been carried sufficiently far, and remove the crucible from the furnace, previously, however, withdrawing a small quantity of the color for inspection, as the test here mentioned is not unerring. When the color proves good, the crucible is left to cool gradually, a cake of red matter is then found at the bottom, and a further quantity, in the form of fine powder adhering to its sides. This latter, being the purest and finest color, is kept separate from the cake. Copperas affords about one fourth of its weight of this color, which alone is used for producing all the various shades of red in the porcelain works of King-te-ching.

White porcelain, made in China, owes much of the fine brilliancy of its color to the oils or varnishes before described; but when a brighter and finer hue than can be thus produced is needed, a mixture of the following kind is prepared. The shores of some of their rivers furnish a species of agate, which is without veins and nearly transparent, so that it approaches to the nature of crystal. This stone is calcined to a white powder, and then ground as fine as possible. To every ounce of this they add two ounces of white lead (ceruse,) also in fine powder, and these being mixed with the varnish, the whole is laid on the porcelain in the same way as other colors. According to the descriptions given to us, this compound, besides being used for the production of a brilliant white, forms also the ground or basis of several other beautiful colors. Their green, which is prepared from the oxide of copper, is said to be converted into a fine violet color by admixture with the white just described. Such a change as this must of course be the effect of chemical action promoted by the heat of the furnace. The mere mechanical mixture of white with green would only reduce the depth of its shade. A very small proportion of the white suffices, it is said, to produce a very deep violet, and the hue is rendered lighter in proportion as the quantity of white is increased. Their yellow is said to result from the mixture, in due proportions, of this white with copperas (proto-sulphate of iron). The accounts we have of those processes among the Chinese, which depend upon chemical laws, are given with so little regard to accuracy, and betray so great a want of scientific acquirement, that these descriptions of their mode of preparing colors cannot be received with any satisfaction.

The Chinese painters of porcelain usually mix their colors with gum water, in which a small portion of either saltpetre (nitrate of potass), white lead, or copperas has been first dissolved. Where a red color is used, the porcelain oil or varnish is applied with it. This color is laid on the ware when in the state of biscuit, that is, when it has been once in the oven, but

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it requires the heat of the second baking to bring out all its requisite shades and tints.

Black porcelain, ornamented with gold, known under the name of *umiam*, is much esteemed in the East. The black is produced by mixing three drachms of deep blue, with seven drachms of the varnish, which they call oil of stones. The black thus prepared is laid on when the porcelain is first dried, and when the black is also thoroughly dry, the vessel is baked. The gold is then laid on, and the piece is subjected to another baking in a furnace peculiarly constructed for the purpose. The gold is ground in water to a very fine powder; and when this has been very gradually dried in the shade, one tenth of its weight of white lead is added, the mixture is incorporated with gum water, and laid on in the same manner as colors are applied.

The Chinese have a kind of porcelain, which is in much repute with them, called *tsou-tchi*. This has the appearance of having been broken, and of having its fractured edges brought together and cemented, and then covered with the varnish originally used. This effect is produced through the peculiar nature of the varnish employed, which never spreads evenly, but has a tendency when in fusion to run into veins and ridges of various and uncertain forms. This varnish is made from a sort of agate stones, reduced by calcination to a white powder, which after being long ground in a mortar is carefully washed, and used when of the consistence of cream. It has been suggested that crystal would probably answer this purpose as well as the coarse agates of the Chinese; and among all the demands of fashion which is ever seeking for something new, it might perhaps serve the interest of some manufacturer to put this suggestion to the proof.

Another kind of porcelain, much esteemed by the Chinese, is called by them *kia-tsing*, which signifies pressed azure. In vessels of this description the colors appear only when the cups are filled with liquid. The manner of making porcelain so as to produce this effect is as follows:—The cup is made very thin, and after having been once baked, the colors are applied in the required forms on its inner surface. When dry, a coating of porcelain earth, the same as that already composing the cup, must be laid on the inside; over this, the usual varnish is laid, so that the colored figures are inclosed between two coats or bodies of the ware. The outside, already very thin, is then ground down almost to the painted figures, which are thus made to appear externally, when they must be covered anew with a coat of varnish so as to be scarcely perceptible from the outside, until the vessel being filled with liquid, this

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acts as a kind of foil behind, and throws out the figures which before were obscured. So much carefulness is called for in the production of kia-tsing, that the art is very seldom practised.

Another admired art among this people is that of producing the semblance of various figures upon pure white porcelain, whose surfaces are yet entirely smooth. Having fashioned a vessel, with the finest materials and extremely thin, it must be polished inside and out, when a stamp cut with the requisite figures in relief must be pressed upon the inner surface of the unbaked vessel. The finest white varnish must next be applied over its entire surfaces, so that the cavities impressed by the stamp are filled by it, and the smoothness of the inner surface is restored. When the ware is baked, the varying thicknesses of the more opaque varnish will be apparent through the transparent sides of the cup, and the whole of the figures will then be seen as finely and accurately traced as if painted on the outside.

The methods employed by the manufacturers of King-teching in applying the varnish, vary with the different qualities of the wares under operation. For very fine and thin porcelain two exceedingly thin coatings are very carefully applied, and some dexterity is required, both with regard to the quantity laid on, and the equable manner of its application. To pieces of inferior quality, as much varnish is applied in one coating as is comprised in the two layers just mentioned. The foot of the vessel is never properly formed until this stage of the manufacture, and after the painting and varnishing have been completed, when this part is finished on the wheel, and varnished likewise. The work is then fit to be placed in the oven.

The construction of furnaces and the system followed in baking porcelain in China differ so little from the structure and method pursued in England, that little need be said here concerning them. It has already been mentioned that the nature of the materials employed calls for a much higher degree of heat than is necessary in our potteries. To insure this, the Chinese are very careful in providing a rapid draught, and in the incessant feeding of their furnaces with small billets of wood, so as to insure its most rapid combustion. The learned Jesuit D'Entrecolles observes, as a thing quite unaccountable, and even inconceivable, if he had not witnessed the fact, that notwithstanding the enormous consumption of wood during so many hours, none of its ashes are ever found upon the hearth of the oven. There would have been greater reason for astonishment had the contrary fact appeared. The rapid draught excited by the disposition of the oven, and the excessive degree

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of its temperature, would serve to carry away completely through the flue so light a substance as wood ashes.

The taste for old porcelain appears to prevail fully as much in China as it has ever done in this country. It is asserted by some persons, that such as was made in former days was not only composed of finer materials, but was more perfect in the mode of its manufacture. Unfortunately for this assertion, there are workmen at King-te-ching, who make it their occupation to counterfeit these much-coveted relics of antiquity, which are called *ku-tong*, and in this they succeed so as to deceive the most observant connoisseurs. In the preparation of these mock antiques there is but little variation from the methods usually practised. They are made thicker than modern porcelain, and are made to undergo the ceremony of burial for one or two months in the most lothesome sink of filth which can be found, by which means every appearance of newness is effaced.

Several reasons are assigned for the high price at which Chinese porcelain is sold in Europe. One of these is, that owing to their very unscientific manner of conducting the baking process, it rarely happens that some, and sometimes a very considerable portion, is not spoilt by unequal or excessive heat, and converted to a deformed and shapeless mass. Another reason for dearness is, the constantly diminishing supply of the materials used, and more especially of fuel, which becomes very expensive. It is added, that as those pieces which are prepared for the markets of Europe, are of patterns unacceptable to the taste of home consumers, and as the factors are exceedingly particular in rejecting every article which exhibits the slightest defect either in form or color, the prices paid to the manufacturers for such as are accepted must be sufficiently high to include the cost of those which are rejected. Notwithstanding these circumstances, the prices at which porcelain is now furnished in China are materially less than those demanded in ancient times, when, we are informed, as much as 100 crowns were given for a single urn at the seat of manufacture. The emperor monopolizes the finest specimens of porcelain manufactured in his dominions, and it has thence been asserted, that none which has ever found its way to Europe gives an adequate idea of the perfection to which the Chinese have attained in this manufacture. The Porcelain Tower erected at Nan-king offers proof sufficient of the very durable nature of their manufacture. This building is of an octagonal shape, is of nine stories, and very nearly 300 feet high, and its entire surface is covered with porcelain of the finest quality. Although this singular and beautiful edifice has been erected more than 400

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